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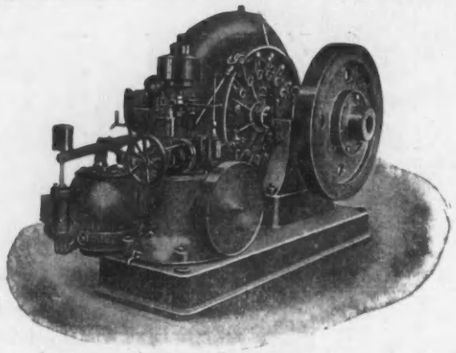

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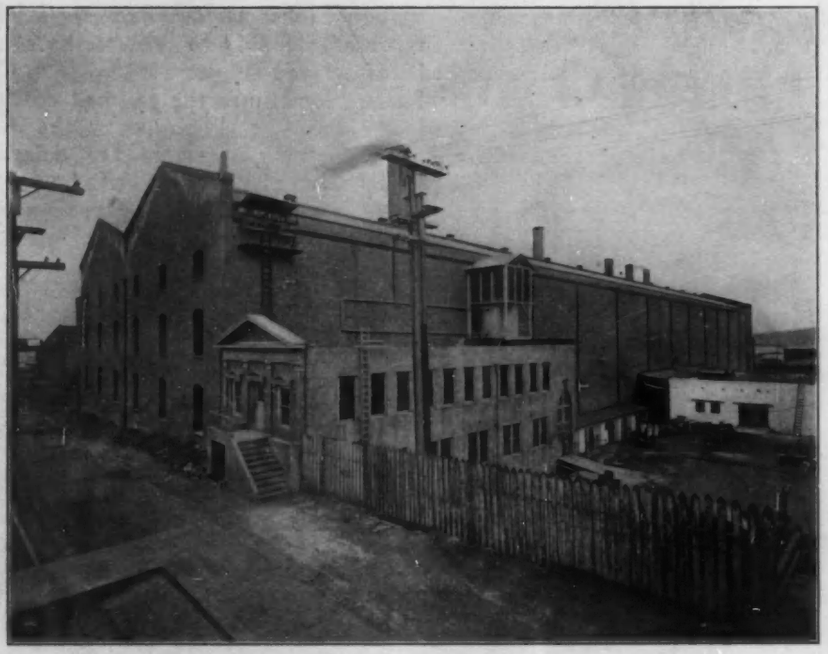
STATION A, SAN FRANCISCO

BY EDWARD STEPHENSON.

Edward Stephenson

Out beyond the Union Iron Works, in the Potrero district, is a huge steam-driven plant that generates much of the electric light and power used in the city and county of San Francisco. The east wall of the building adjoins the great Spreckels Sugar Refinery, because when this electric plant was established about ten years ago it was owned by Claus Spreckels, who also owned the substantially rock-ribbed shore land on which it stands. The natural solidity of the site accounts for the splendid manner in which the building and its foundations have stood earthquake tremors and the constant vibrations of the massive machinery. As there are eleven water-driven and eight steam-driven electric plants in the system controlled by the Pacific Gas and Electric Company this generating plant is designated as Station A.


Station A, San Francisco.

In size and output it is one of the largest plants of its kind west of Chicago, and it requires the expert services of one hundred men to operate its machinery.

The building is an immense brick structure extending from street to street through a city block. It is 450 ft. long, 140 ft. wide, and 80 ft. from its fireroom floor to its steel-ribbed roof of galvanized sheet-iron. A division wall runs the entire length of the building and makes of it two big rooms of equal size.

The long room on the east side of this double building (the left-hand side in the picture) contains the twenty-seven steam boilers, the six boiler-feed pumps, the one salt-water fire-pumps, the five economizers, the three auxiliary exhaust feed-water heaters, the four fuel-oil pumps, the five fuel-oil heaters, and all the steam and water piping necessary to the operation of this big modern boiler plant, which has six smoke stacks and four induced-draught fans to accelerate the draft in the boilers and economizers. The long room at the west side is the engineroom, and it also contains thirteen electric generators. Ten of the generators can supply San Francisco with all the electric light and power the city ordinarily uses.

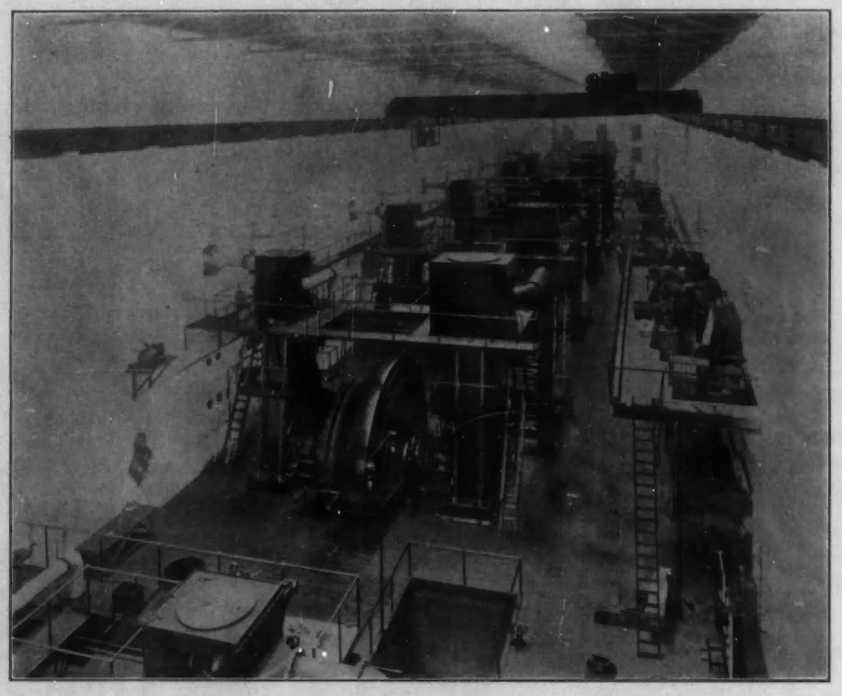
Three of the generators are used to supply the exciting current to run the ten others. The foundations for these big generators are built up 15 ft. above the main floor, and on a level with the tops of these generator foundations is the floor of the engineroom. On the main floor, which is below the level of the gen-

erators and the engineroom, are installed all the condensers, air-pumps, pipes and such other equipment as can be placed below the engineroom floor.

Before the plant was finished it was sold by Claus Spreckels to the San Francisco Gas and Electric Company, and then the installation was completed.

The accompanying view of the outside of the building conveys a very good idea of its massive construction and size.

The boilers in this building are capable of daily converting 2,000,000 gallons of water into steam at a pressure of 200 pounds to the square inch. About thirty miles of four-inch boiler tubes are contained in the boilers and economizers. It is not often that the maximum capacity of the plant is needed, yet in winter time, during the period of short and dark days, it is quite usual to evaporate 5000 tons of water a day and convert it into steam. The production of steam is the first step in a steam plant's generation of electric light and power.

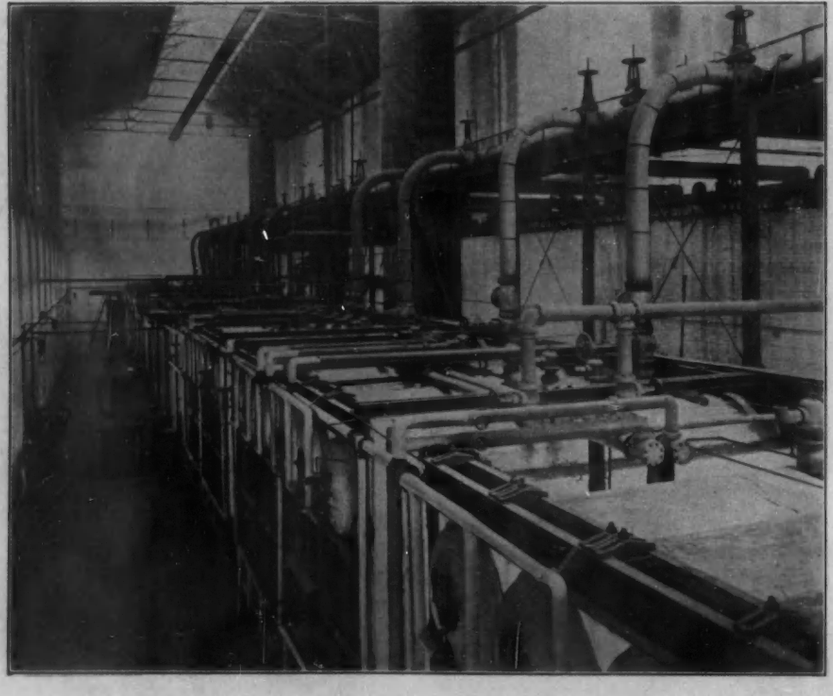


View of the Engine Room, Looking South.

To change 5,000 tons of water every twenty-four hours into steam at 200 pounds pressure requires an enormous amount of fuel. So much fuel is needed that if coal were used this great plant in itself would consume more coal every day than it now daily used in the entire city of San Francisco. But fortunately the fuel is crude-oil.

This plant uses 100,000 gallons of fuel-oil a day. But to handle this immense amount of oil happens to be about the easiest and simplest work about the station. Of course fuel-oil cannot be left round like coal. Elaborate containing tanks must be provided. They must be of a size sufficient to store a large reserve supply to protect the plant against the risks of delayed delivery.

Sometimes the railroad company cannot get the oil-tank cars through from the wells. Sometimes the oil-carrying steamers are delayed. Sometimes the cross-country oil-pipe lines burst or need repairs. But despite any or all of these uncertainties, Station A must keep going and keep giving to the people of San Francisco all the electric light and power they require.



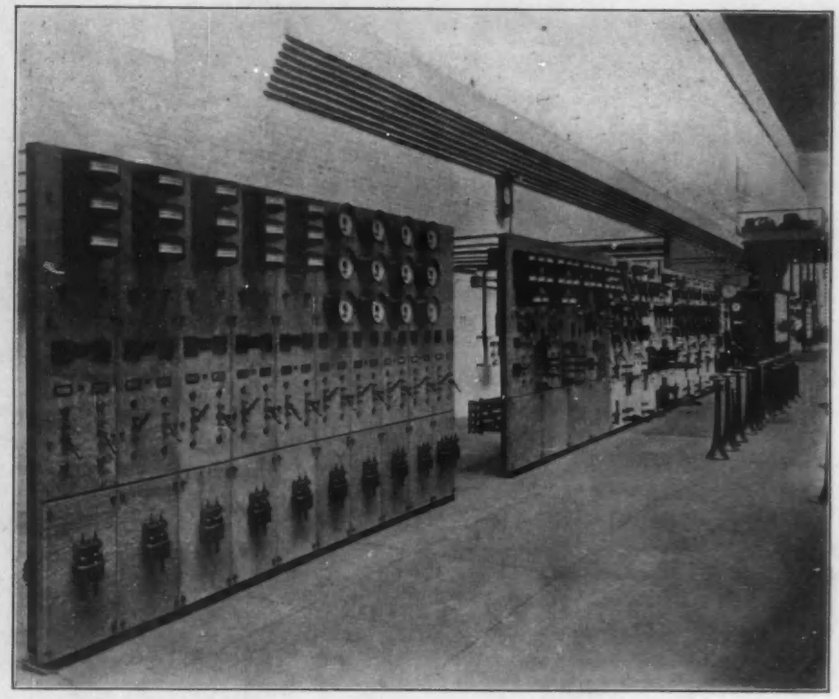
View of the Boiler Room, Looking South.

The forethought of the company management in supplying such ample storage capacity at Station A. has averted shut-downs. When the oil company has been short of oil the large reserve storage at Station A has given it a a place from which to secure a temporary supply.

Steamships carrying 50,000 barrels, or 8,000 tons, of fuel oil can come alongside the company's own wharf near its plant and discharge their oil cargoes directly into the storage tanks in about fifty hours. As there are two separate pipe lines the oil cargo from two oil-boats can be pumped out at the same time. Probably no other electric light and power plant in the world can handle

its fuel in such large quantities and so quickly as can station A. Fifty thousand barrels, or 8,000 tons, of oil can be received at one time in oil cars on the plant's own spur tracks, but the operation of pumping out the tank cars is slower than the pumping of the same amount of oil from the ships.

After the production of steam the next step in the making of electricity at Station A is the use of this steam to run the electric generators. Reciprocating engines are used to revolve the generators. Six of these engines are of the McIntosh and Seymour standard compound type of 2,200 h.p. capacity at normal load, two are of the Union Iron Works type and design similar to those used on the latest American battleships built by the Union Iron Works. These last two engines were rated by the Union Iron Works at 4,800 h.p., but even after years of use the normal capacity of these two engines when working with the greatest ease and smoothness is about 6,300 h.p., or more than 31 per cent greater than the makers guaranteed.



Stationary Switchboard in the Engine Room.

Every engine is supplied with condensers and air-pumps which are intended to receive and condense into water all the exhaust steam from the engines. This distilled water is then pumped back again into the boilers. Thus the cycle is maintained; the water condensed into steam, the exhaust steam converted again into water, and this water sent back into the boilers to be reconverted into steam, the endless round being maintained as long as the plant is operating.

Some idea of the length of time this operation has been unceasingly continued may be gained from the explanation that some of the engines have revolved more than 500,000,000 times since they were first installed.

In changing the exhaust steam from these engines back into water it is necessary to cool the steam until its latent heat has been abstracted. This cooling operation requires the use every day of about 75,000,000 gallons of salt-water. That is twice as much water as the Spring Valley Water Company daily supplies to the entire city of San Francisco. To put it another way, Station A has to pump 150 gallons of water a day for each of the 450,000 people in San Francisco in order that the whole city may have the electric light and electric power it needs.

The work of raising this salt-water requires four centrifugal pumps driven by electric motors. These four pumps are housed near the waterfront, about 1,000 ft. east of Station A. The salt-water comes in from the bay 500 ft. through a canal that is about 50 ft. wide at the bay end and 20 ft. wide at the pump end. The pumps are of the Byron Jackson type, and they work under a head of 50 ft. Three of them have a capacity of 30,000 gallons a minute, and the fourth has a capacity of 20,000 gallons a minute. They all discharge into a great thirty-inch cast-iron main, extending 1,000 feet to the electric plant. After this pipe reaches the station it has outlets at each condenser, at each cooler, and at any other places where salt-water may be required. Each outlet is provided with strainers of a standard pattern to intercept any dirt that may have passed the primary strainers at the suction end of each pump in the channel.

To keep all this system of machinery in repair and running smoothly requires the services of one hundred men, each an expert in his particular line. And when each man does his work well and gives full vent to his knowledge of the subject, then Station A is entirely successful; and I am proud to say that this condition has been generally maintained. It is creditable to the men themselves that the efficiency at Station A is much higher as the years go by and the plant and the machinery grow older. This higher efficiency is due to the systematic way in which the men at this plant pull together and observe the rule that "a stitch in time saves nine." They not only put in the timely stitch, but, if the place be thin, they put on a patch in time and make things more secure. And the end is not yet, even after Station A has generated more than 500,000,000 kilowatt hours. She is still a big, sturdy, reliable producer of electric energy, because the men and the machinery keep working smoothly.

The United States Civil Service Commission announces an examination on March 29, 30, 31, 1910, to fill eight vacancies in the position of skilled draftsman, at salaries ranging from $900 to $1,200 per annum, in the office of the Chief of Ordnance.

WATER SUPPLY AND TREATMENT FOR POWER PLANT PURPOSES[1].

BY WILLIAM MILLER BOOTH.

The price of raw material, of fuel, labor conditions and freight rates are important factors to be considered when a new industrial plant is to be built. Less often investigated, yet of primary importance is the presence of a constant supply of good water. If possible two independent sources should be made available. It is not a large manufacturing concern that requires boilers of 1,000 h.p. capacity. If run 10 hours per day these evaporate approximately 170 tons of water. When condensing engines or turbines are used, from 14 to 17 times as much water is necessary to return the steam again to its original state, or about 2,500 additional tons—in the aggregate more than 9,000 pounds per minute.

The quality of the water is not a matter of indifference, as modern power house apparatus makes exacting demands of the medium passing through and over its parts. It will readily be seen that choice of water requires knowledge of power plant conditions and should not be handled in a haphazard way. While our population and manufacturing interests constantly increase, available water is decreasing, especially in our small streams that flow through densely settled districts.

Given two sources, the use of that which entails the least cost is naturally considered—the quality is often neglected. Unfortunately water exactly adapted to boiler use is seldom found in nature. For convenience we classify waters as follows:

AVAILABLE SUPPLIES

Class—Source.	Contain	Action in Boilers.
Soft—		
Rain and snow water from granite	Ammonia Salts	Corrosive
Returned	Alkali	Negative
Swamps	Ammonia	Corrode
Lakes	Organic matter	Corrode
Large rivers	Calcium and Magnesium Salts	Slight scale
Hard—		
Springs	Lime, magnesia, iron	
Lakes	Sulphates	Scale forming
Small Rivers and Creeks	Chlorides	
Wells	Carbonates	
Saline—		
Sea		
Well	Lime, magnesia,	
Mineral Springs	Sulphates, Chlorides and Carbonates, Sodium and Potassium	Scale forming
		Corrosive
		Foam
Alkaline—		
Streams from Western Plains	Sodium, Chlorides, Sulphates and carbonates, Silica, Lime,	Foam
Springs	Magnesia	
Acid—		
Mineral Springs	Hydrogen	
Wells	Sulphide	Corrode
	Iron Sulphate	
Coal Regions	Sulphuric acid	

Soft Water.

The first group includes rain and snow waters that are free from scale-forming materials, but which contain organic matter and in the first instance may have a strong acid reaction. The use of such waters is attended with danger from pitting. Harder water should always be mixed with these, or a slight excess of alkali may be added.

Precipitated waters flowing over granite rocks are ideal for boiler use, as enough alkali is absorbed to prevent pitting. Water from wells, driven in granite and quartz sand to a depth of sixty feet, has been found to possess a hardness varying from .5 to 2 degrees Clark—pure water being unity.

The only distilled water practicable for boiler purposes is that returned from vacuum pans, pumps, engines, turbines, surface condensers and heating systems. Condensed water from turbines containing no oil ought to be ideal for boiler use. We have, however, had an instance of severe corrosion resulting from the use of such water with a proportion of fresh hard water added at each return to the boilers. Returned turbine water should be made slightly alkaline. We believe that the open heater and hot well should be much more generally used and that a good oil separator is indispensable in any large plant. Anxious to keep his apparatus well lubricated the engineer often uses an excess of oil which makes it difficult to utilize the condensed water. A large amount of energy escapes daily from many plants through heated water that runs to waste, in addition to the loss of soft, scale-free boiler water. Many engineers suffer from oil at the surface of the water in the boiler; the gauge glass showing this condition quickly. If mineral oil is used in the power plant we do not worry about the presence of a small quantity in the boiler, but prefer to keep it out.

Another class of soft waters is found in the lowlands of the coast. A heavy rainfall with finely divided organic matter and heat, combine to charge standing water with organic matter which may be acid in character. Boilers using such water suffer from corrosion and require alkali.

The waters of some lakes, large rivers and a few deep wells deposit little scale and may be termed "soft." Arbitrarily we fix the hardness under 3° Clark. Such waters contain suspended particles, sand, clay, leaves and dissolved organic matter, the quantity of these varying greatly during different seasons. These require considerable blowing down at the boiler. Water of this character is improved by sedimentation in large tanks followed by upward filtration through coarse material, as sand, coke breese or excelsior.

We insist that water for boiler purposes shall be clean. Sewage laden lake or river water carries grease which accumulates upon the headers of water tube boilers and corrodes the tubes and shells of tubular boilers. Our clients are much annoyed by such water. We recommend sedimentation, upward filtration and legal proceedings against the corporation or individual contaminating the stream. This applies particularly to abattoirs, rendering plants, woolen mills and cities. As a last resort we recommend chemical precipitation and filtration.

Hard Waters.

A large proportion of our water supply is scale forming. If ten grains of this material per gallon are present nearly 140 pounds of sludge and scale will concentrate, in a 24-hour, 1,000 h.p. plant. This interferes

[1]Abstract of paper presented at the Twenty-Ninth Annual Convention of the American Water Works Association.

with the operation of the boiler as a steam producer. In many samples of water, carbonates vary from 3 to 15 grains per gallon and sulphates from a trace to 120 grains per gallon. What these compounds are and how they are formed will not be discussed here.

Organically pure but hard sources of supply are used by many cities and towns to the disadvantage of manufacturers. We have suggested in a previous paper that large operators should combine to manufacture soft water for their common use. Water companies might soften supplies furnished certain districts. We believe that scale-free, clean water is worth 10 cents per 1,000 gallons. It usually costs less than 3 cents to soften this.

Many manufacturers drill deep wells to provide drinking water and to serve as an auxiliary supply. We suggest consultation with a practical geologist before putting a large amount of money into such an enterprise.

Having been fortunate enough to obtain water this may be of any class mentioned in the table. For power plant purposes heavily charged mineral waters are to be avoided. Calcium and magnesium carbonates and calcium sulphate are scale producers. Chloride of magnesium corrodes metal and sodium chloride accumulates on all semi-heated surfaces. For boiler purposes we have not been troubled by the precipitation of iron found in natural waters. If water from a well contains all of these forms of impurity in any considerable quantity it should not be used for power purposes.

Those who drill wells should take samples of the strata and water encountered. Analysis of these will show what veins of the supply are to be avoided and cased out.

Saline Waters.

Few waters are free from chlorides. Common salt is not considered scale forming, although large quantities are not easily handled, while the chlorides of calcium and magnesium are very objectionable in a boiler. We have no remedy to offer for heavily charged saline waters. Evaporation results in choking boilers and condensers.

Alkaline Waters.

Some waters contain carbonate, chloride and sulphate of soda and potash with perhaps chlorides of calcium and magnesium.

This is particularly true of waters of the western plains and lakes. As an extreme instance we submit the following analysis of a water sent us from a California lake:

GRAINS PER U. S. GALLON.

Silica	14.35
Alumina	trace
Oxide of iron	.00
Calcium carbonate	trace
Magnesium carbonate	.00
Potassium chloride	93.56
Sodium chloride	2,754.30
Sodium sulphate	610.50
Sodium carbonate	2,573.10
Acid carbonate of soda	248.50

This is a representative of very bad alkali water, which could not be used for technical purposes. If a boiler is clean we find it almost impossible by adding alkali to produce foaming. This has been proved with an excess of soda ash amounting to 50 grains per gallon.

Acid Waters.

Water from expensive wells sometimes tastes and smells of hydrogen sulphide. If at all strong engineers will usually not allow such water in their boilers. We believe that, should circumstances warrant the outlay, a heavily charged sulphur water could be successfully prepared for boiler or other industrial use.

Water from the mining districts often contains sulphate of iron. We consider this dangerous water and suggest treatment before use.

Some waters contain free sulphuric acid. Sometimes such water is supplied naturally, but generally this is found in sludge from acid plants, coal washers or refineries. No more dangerous material can find its way into the boiler.

A sample of scale from boilers in a Pennsylvania steel works was practically pure oxide of iron, the result of an acid supply.

We devote the remainder of this article to methods of handling scale-forming, saline and alkaline waters.

Three principal uses of boilers afford a natural division as follows: Marine, locomotive, stationary.

Marine boilers are generally supplied on coastwise steamers, tugs and harbor craft with soft water that is obtained at one of the ports at which the vessel touches. As many of the engine cylinders are run without oil, the returned water is used again. Trans-Atlantic steamships are supplied with surface condensers and complete distilling outfits of expensive design and the softened water is used again.

Locomotive boilers represent an enormous horsepower and need the best water obtainable. Hard water only can be found on many lines. Sometimes a soft supply is found at one end of a division and hard water at the other. Alternate use keeps the boiler free from scale. Starting and stopping and generally in motion, the alkaline content of a locomotive boiler water must be kept low. With sludge, serious foaming may result through the use of an excess of softening agent. This subject demands immediate attention on the part of all railroads. Western systems have done more in this respect than those in the east.

Our experience with stationary boilers has been divided between shell and water tube types. Methods of water treatment apply in a general way to either, although many disadvantages of hard and muddy water are overcome in water tube boilers.

Engineers in charge of steam plants are usually ignorant of the principles of water purification. This is only partially their fault, as literature for their education has only recently been available. There are many plants the boilers of which cannot be operated a single week without a deposit of scale serious in character and quantity. The most easily procured remedy has been the "compound" furnished at an inflated cost. The introduction of the softening plant has widely advertised the fact that lime, soda ash, caustic soda and tri-sodium phosphate are cheap and efficient scale removers. Many an engineer spends the Sabbath day hammering scale only to repeat the operation the Sunday following. This is usually unnecessary, as proper chemical treatment will remove the scale formed and prevent the deposit of more.

The actual cost during the past seven months to

keep boilers clean in a 2,000 h.p., 24-hour plant has been less than $15, the hardness of the water being 5° Clark. Caustic soda and soda ash have been used in slight excess.

Ideal conditions favor the installation of a standard softening system. We feel, however, that prejudice is so great that it will take at least five years to make these plants popular with engineers, who have in many instances received gratuities from compound salesmen, or with managers who cannot see an adequate return for the investment.

We now turn to methods of treatment.

While waiting for a better understanding of the correct thing to do when annoyed by hard water we have adopted the following method, which is now used in many plants. Analysis is made of the water supply or supplies; of the water from the heater, from each boiler and from the hot well. In this way we find remarkable conditions. The hardest water that has come to our notice was taken from three water tube boilers: 1, 43° Clark; 2, 85° Clark; 3, 382° Clark.

It is not unusual to find alkalies and scale-forming ingredients concentrated in the boiler water. If the supply has a hardness of 10° Clark, the internal water may have a hardness of 20, 30 or even 40 degrees.

Great stress has been laid on the removal of carbonates by heaters. We find carbonates in most boiler waters and believe that the best heaters may remove 50 to 75 per cent of these. The water circulates too rapidly to favor their deposit and the dissolved gases are occluded under pressure. The concentration of chemical salts in the presence of organic matter may cause serious corrosion. We believe that sulphates of calcium and magnesium may produce or aid in producing the holes that are eaten in feed pipes and flues, heretofore credited to chloride of magnesium, but which we find may occur when none of this chemical is present. Further investigation must be made to determine the exact cause of the foregoing results.

Having proved the presence of concentrated salts in a set of boilers, we suggest to the engineer that he shall "blow down" once in four hours or two or three times per day from one-half to two inches of water. This form of treatment some engineers will not adopt, stating that it will strain their boilers to blow them under full steam pressure; others do this regularly. We have a plant of this kind in mind where there are two 200 h.p. shell boilers that have been blown down under full head of steam perhaps two inches each afternoon for four years with no injurious results.

The scale-forming materials separate in the boiler, the decomposing carbonates rising to the top and forming a light scum, which accumulates on the upper tubes, while the sulphates and precipitating carbonates form a dense, heavy scale on the shell and lower tubes of the boiler. We believe that it is a very good plan to blow out the accumulated sediment in the morning and in the evening, and that considerable scale may be removed from the water surface while the boiler is under full steam pressure, by opening suitable cocks.

Boilers are set in peculiar ways either accidentally or through ignorance. We have found boilers with the blow-off at the rear no less than four inches higher than the floor of the boiler at the front. In some boilers the blow-off is found three or four inches above the lowest point of the shell, and we find engineers who blow their boilers but once per week, putting in from one to five gallons of compound Monday morning, and making this last the entire week, blowing it out at the close of the working day Saturday. Severe scaling or severe corrosion may result from the lack of use of the blow-off valves. If we are running a boiler or a battery of boilers using hard water, we would use the blow-off at least three times during the 24 hours. Lack of attention regarding falling scale and accumulating sludge may result in a bad bag or blister of the crown sheet.

The Prescription.

If the engineer finds that he cannot handle the sludge through the blow-off valve (and this the chemist can determine usually in advance), a mixture of alkali should be used in the boiler. This is added with the feed water drop by drop. The quantity bears but little relation to that prescribed for the same water in a water softening outfit. For instance, the prescription may call for five pounds of soda ash and two pounds of caustic soda per thousand gallons of raw water. If this is placed in the boiler in exact proportion to the number of thousand gallons used the chances are that very severe foaming will result during the coming three days. We prefer to divide the prescription by at least five and then test samples of water taken from the boilers under treatment, making a careful analysis of such treated water. In this way we are able to determine the quantity and amount of chemicals absorbed and those left in solution, also the quantity and amount of scaling material removed, and that left in the water.

The scale that accumulates on the tubes and shell is often useful in determining the kind of treatment that a boiler needs, but this scale may differ materially in composition at different points in the boiler.

The use of boiler compounds containing tannin is determined by black scale which is a dye formed by the union of tannin and iron at the expense of the boiler itself. We discourage the use of such compounds.

Objections are raised by some engineers to the use of soda ash in boilers. We have yet to find a single instance where soda ash is used in moderate quantities—even to 50 grains per gallon in excess—has injured a boiler shell or tubes, and would much prefer the use of a small quantity of this material in a boiler water to the use of rain or distilled water, both of which have a highly corrosive effect on iron. Again, some engineers state that soda ash injures gaskets. During two seasons we have tried this out in a 2,000 h.p. plant where the steam is used for heating houses and office buildings, and although expensive and complicated steam traps, meters, and gaskets are used throughout the system, we have failed to experience any difficulty whatever from this method of treatment.

Having reckoned the amount of caustic lime required to remove carbonates from the water for internal treatment we use a fraction of its equivalent of caustic soda. With carbonic acid this material is changed to sodium carbonate and if sulphates are present a second reaction takes place. A much smaller proportion of soda ash is required than when lime and soda ash are used.

On account of this double action, we believe that caustic soda should be used much more generally in water, as it is more easily handled than lime and as, further, a concentrated solution can be made. After the preparation has been applied and an analysis of the water has been made, it is not difficult to see what changes are necessary. These should be applied at once. Any form of exact treatment for boiler water within or without the boiler, demands the services of an experienced chemist and an interested engineer. An excellent water softening apparatus failed because the engineer in charge would not give it fair treatment.

Those in charge of power plants are usually anxious to learn some of the principles involved in water purification. It has been our practice to supply a regular outfit for their use. This includes the following: 1 glass burette—funnel and filter papers, 1 bottle phenolphthalein solution, 1 bottle methyl orange solution, 1 bottle silver nitrate solution, 1 quart of soap solution with the formula for making up more, and sometimes a bottle of standard decinormal hydrochloric acid. This apparatus is purchased by the power plant owner, and placed in the engine room. We have been told by one engineer that he would not take one hundred dollars for the little kit of tools provided to determine the processes going on in the boiler water. The number of tests that these men will make and the care and accuracy exercised in making them are surprising.

Water Softening Plants.

As there are now several forms of water softening apparatus on the market that are entirely efficient, the power plant manager and operator have no excuse for using a scale-charged water. With a thousand horsepower or a larger plant and with water about 10° in hardness, a water softening outfit can be shown to be an investment paying more than 10 per cent on its cost and operating expenses. In some instances this percentage may be raised to a point where the whole apparatus will pay for itself within two or three years. There is great prejudice on the part of engineers to the use of softened water, and we have found men who have put in expensive plants of this sort who are not operating them. The reason being that "they're too much bother."

Considering the cost of extra fuel, flues, the cost of opening the boilers, removing scale and poor steaming capacity, a scale-free water is a valuable investment. We find plants that are operating with boilers that have not been opened for months, and that are found in a scale-free conditions, the water being of a hardness of about 20° Clark per U. S. gallon. Originally we were not sure of the action of caustic lime and soda ash on concrete tanks, but believe that with a carefully constructed tank of this kind no danger whatever will result through the action of the alkali on the cement mass. A tank has been in use for this purpose for three years and is still in first-class condition.

The ideal chemical for softening water is not now available. Calcium, magnesium and the sulphate radical should be removed. Excessive foaming would be avoided and softened water would approximate distilled water in purity.

FUEL OIL.

BY R. F. CHEVALIER.

The various engineering magazines have from time to time treated with the subject of boiler economy, and in the last year have laid particular stress upon flue gas analyses in connection therewith. All of the articles, or rather all that have come to the writer's notice, have treated on this subject where the fuel used was coal. The reason for this is apparent. It is only within recent years that oil as a fuel has been used to any extent, and then only locally.

The quantity and grade of the oil produced in California required other means for its consumption than the refineries. Large quantities are produced that have no value except as fuel. This led to the gradual use of oil fuel, the advantages of which were so apparent and the saving effected over coal so large, that when the supply was assured, it was rapidly adopted as the main fuel on the Pacific Coast.

At first the decrease in the fuel bill was so marked that very little, if any, attention was paid to economy. Since the price of oil has increased, more attention is paid to its economical burning. Many types of burners have been invented to perfect atomization and minimize the amount of steam or air required to do the work. Various forms of furnace construction and draft arrangements have been tried with more or less success.

Summing up the practice of burning oil as fuel today, it develops that the method of handling and of combustion has not yet been thoroughly mastered. Boilers have been and continue to be fitted for the use of solid fuel, and the discarding of this practice does not seem an easy process. Designers and builders of boilers apparently are not able to thrust aside the methods used in baffling, size of gas passages and numerous other details for burning coal.

The furnace-arrangements are not as efficient as they will no doubt become. The conditions under which the fuel should be burned are not yet thoroughly understood. The firing of oil seems a simple matter, yet its economical burning requires considerable scientific investigation, coupled with practical knowledge.

The purpose of the papers to follow is to deal with the various problems connected with the combustion of oil fuel. It is proposed to introduce everything up to the most recent practice.

The writer desires to state that he has no connection with any burner or appliance described in these papers, and wherever comparisons are made they will be used as matters of fact for the information of the reader with the intention that such information shall be reliable. The same may be said regarding any data on fuel. The subjects treated will be:

(1) Fuel oil; (2) its combustion; (3) gas analysis; (4) drafts and temperature measurements; (5) burners; (6) furnaces; (7) test data.

The writer invites suggestions for the treating of the various subjects, and if receiving any contributions that will be of any benefit to the readers, will gladly embody such in the papers under their respective headings, giving due credit therefor.

(To be continued.)

PRACTICAL MECHANICS.

Paper No. 10.

(Belting—Continued.)

In the preceding paper the calculations incident to ordinary belting practice were shown. A diagram was given from which values of the rather complex expression for the belt friction and angle of contact may be found. The final results had to be obtained, however, through the application of values to the mathematical formulas. Further, the computations thus far have taken no consideration of high pulley speed and the resulting inertia effect known as centrifugal force. In reality the formulas thus far developed are not sufficiently complete and comprehensive to be of general usefulness. They are, rather, expressive of the laws of variation of the quantities and terms involved.

In the present paper it is intended to combine with the foregoing the effects due to high pulley speed and finally to reduce the whole to a simple diagram from which results may be read off without the use of mathematical computation.

Let us study the forces which exist when a belt section arrives at a pulley and the interrelations of these forces as this section travels around the pulley. The tension, T_2, in the belt as it reaches the pulley is gradually increased on the way around the pulley to T_1 at the point of leaving. It is therefore variable. Due to this tension there is a resulting force normal to the pulley surface, or radial, and acting toward the center of the pulley. This force is likewise variable.

Opposing this normal inwardly-directed force there exists an outwardly-directed force which is constant for all portions of the pulley surface, but which increases with the square of the pulley speed. That is, if the pulley speed is doubled this centrifugal effect becomes four times as great. It varies also inversely with the pulley diameter. To get an expression for the resulting pressure of the belt against the pulley involves, therefore, consideration of these two opposing forces at each minute portion of the arc of contact; the total normal pressure being the summation of all these portions.

This can be shown mathematically to be expressible in the form $T_1 = T_2 e^{\alpha \phi} \left(1 - \frac{n v^2}{g}\right)$

In addition to the terms before defined we have here:

n = a constant depending on the weight of the belt.

g = the constant 32.16.

v = the angular velocity of the pulley.

Let us examine this equation. The term $\frac{n v^2}{g}$ will increase as the square of the angular velocity (v) of the pulley. When this angular velocity increases therefore the quantity in parenthesis $\left(1 - \frac{n v^2}{g}\right)$ decreases, and hence the horsepower decreases. At the speed where $\frac{n v^2}{g} = 1$ the quantity in parenthesis becomes 0, and $e^0 = 1$. Hence the horse power becomes 0 since the terms within the brackets become

$$\left(\frac{1-1}{1}\right) = 0$$

In reality this is the critical pulley speed at which the belt would begin to leave the pulley. There would be no normal pressure against the pulley and consequently there could be no power transmitted.

This general formula could be used in any case the engineer might have at hand, and by choosing the appropriate constants for maximum allowable pull, belt speed, coefficient of friction and angle of contact, the horsepower that an inch of belt would transmit could be readily figured. Such a computation would be tedious, however, and to avoid it the accompanying diagram has been worked out by Prof. J. Flather for values of the constants which experience has shown to be good practice.

The belt speeds in feet per minute are at the bottom; the horsepower for large pulleys at the left and right sides, and the angle of contact on the smaller pulley is given at the top. Four curves are drawn in the body of the diagram; two for double belts and two for single.

The diagram is used as follows: Starting at the figure represented by your belt speed as decided upon, proceed upward to the curve of the belt to be used. Then follow a horizontal line to the center line of the diagram, i. e., to the 180° angle of contact. This horizontal line corresponds to the value of the horsepower which one inch of such belt would transmit if the belt covered one-half of the pulley. If the angle of contact is other than 180° proceed parallel to the sloping lines until the vertical line corresponding to the angle of contact is reached; thence horizontally to the right or left margin. The value of the horsepower thus found will be that transmitted for this angle of contact and per inch of width.

For example, suppose we wish to transmit 50 h.p. at a belt speed of 3,500 ft. per minute and shall use a double laced belt. Let us say that the speed ratio is such that but 160° of the smaller pulley is covered by the belt.

Going vertically upward from the 3,500 point of the bottom scale to the double laced curve, then horizontally to the center line of the diagram, we find that at this speed the belt would transmit 5¾ h.p. if covering 180° of the pulley. Proceed now from the 180° line along the sloping line to the 160° vertical line, and thence horizontally to either margin. It is now found that but 5¼ h.p. will be transmitted. Dividing 50 by 5¼ gives 9½ inches, the necessary belt width.

When very small pulleys have to be used with large belts there is less tension permissible owing to the injury resulting from bending. This is provided for in the diagram by the diagonal lines drawn from the lower right-hand corner. If, for instance, the belt above determined were to be used on a 12-inch pulley, follow horizontally along the 5¼ h.p. line to the 12-inch pulley diagonal line and thence vertically upward to the small pulley scale at the top. It is seen that but 4¼ h.p. could be transmitted in this case. It is seen by observing the diagram that the power transmitted increases with the belt speeds up to a certain maximum value beyond which it decreases, finally

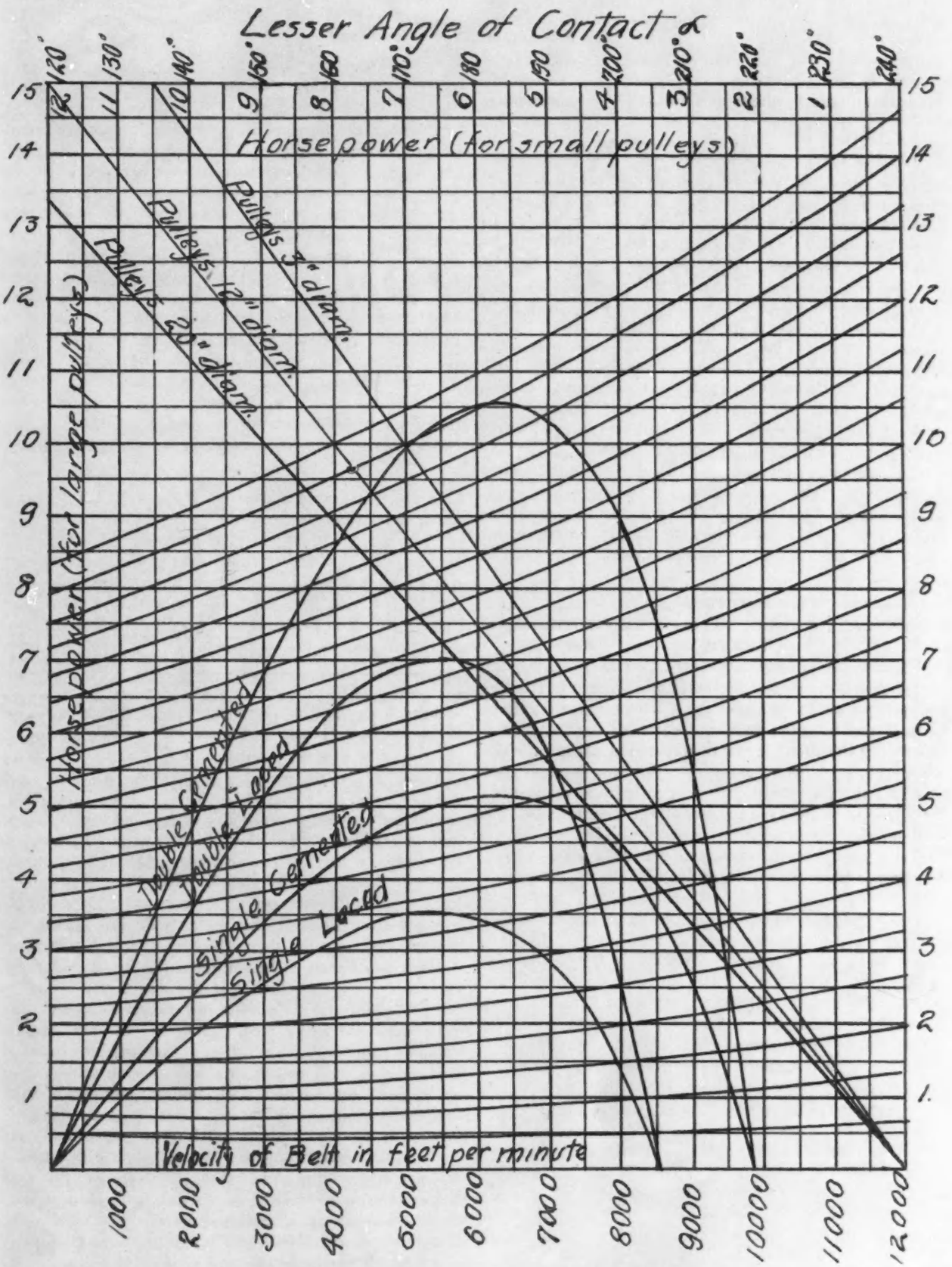

Lesser Angle of Contact α
120° 130° 140° 150° 160° 170° 180° 190° 200° 210° 220° 230° 240°
12 11 10 9 8 7 6 5 4 3 2 1
Horsepower (for small pulleys)
Pulleys 3" diam.
Pulleys 12" diam.
Pulleys 20" diam.
Horsepower (for large pulleys)
Double Cemented
Double Laced
Single Cemented
Single Laced
Velocity of Belt in feet per minute
1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1.

DIAGRAM FOR FINDING HORSEPOWER TRANSMITTED BY BELTING

For explanation see page 252.

falling to zero at about 10,000 ft. per minute for double belts. This is simply the graphical explanation of the effect produced when high pulley speeds are encountered, and is the plotted results of the mathematical equation where the term $\frac{n\ v^2}{g}$ approaches and reaches unity.

From a series of observations extending over a period of nine years, Mr. F. W. Taylor (see A. S. M. E. trans. Vol. XV., p. 204) drew the following conclusions relative to belting practice: "A double belt, having an arc of contact of 180° will give an effective pull on the face of the pulley of 35 pounds per inch of belt width.

"The number of square feet of belt passing around a pulley per minute required to transmit one horsepower is 80 ft. for oak tanned and fulled leather belts and 90 for other types of leather belts. The number of lineal feet of double belting one inch wide passing around a pulley per minute required to transmit one horsepower is 950 ft. for oak tanned and fulled leather belts and 1,100 ft. for other leather belts."

These values given by Mr. Taylor are rather more conservative than those established by other engineers, but this fact is explained as due to the desire on his part to establish a belting standard that would stand for a maximum of reliability rather than a minimum first cost.

CALCULATION OF STEAM ENGINEERING TESTS.

Every steam engineer is at some time during his career called upon to make tests of an engine or boiler or perhaps of an entire plant. The results of these tests if put into the proper form may be the means of causing the manager or owner of the plant to make certain changes in the plant. These changes are bound to effect the engineer. There may be new machinery installed or economy devices; or the character of the load on the plant may be readjusted. In any event, the engineer who has done the testing and experimenting is almost certain to benefit by the results of such tests. The decision of the man in authority, however, will very greatly depend upon the nature of the report he receives from his engineer. If it is based upon sound conservative figures logically deduced from correct observations and intelligibly arranged, the report will have weight with the man to whom it is submitted. Inaccuracy, incompleteness, or ignorance on the part of the engineer, may, on the other hand, be the cause of the manager's rejection of the entire recommendation, even though the cause for such recommendation may be just as urgent and advisable as in the case of the well deduced report.

It behooves every engineer to know how to use the instruments and apparatus with which the results of experimental tests and observations are reduced to terms and values understood by the business man.

In steam engine testing the equipment with which the engineer should be familiar consists of

1. The indicator;
2. The calorimeter;
3. The prony brake or dynamometer.

Besides the necessary steam tables, the following instruments are necessary and should be thoroughly understood:

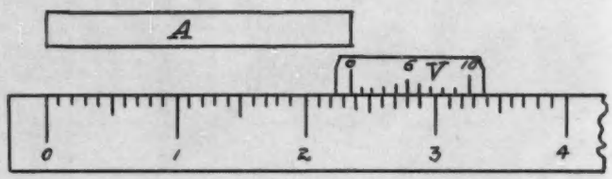
1. The vernier;
2. The slide rule;
3. The micrometer caliper;
4. The planimeter.

The literature covering these various instruments and their uses, while complete, is so scattered among the various books and engineering works, and the explanations are often given in such mathematical mazes that the engineer seldom has the information necessary to get up a thorough report, or even to set up his apparatus correctly before taking the necessary observations.

We therefore intend to assemble this literature and place it before the stationary engnieers so that it may be in practical and convenient form. In doing this, free use will be made of whatever literature may be found on the subjects under special consideration, and with the exception of occasional extensions for the purposes of more complete simplification, no claim toward originality is made.

The Vernier.

The vernier is a device for reading a scale more accurately than is possible with its finest division. Verniers are employed on either straight or circular scales; on the former where extreme exactness is required in determining linear distances with calipers or straight edges, and on circular scales where exact angles are to be measured. Circular verniers are to be



The Vernier.

found on surveyor's transits, or micrometer calipers, and on certain forms of polar planimeters. The vernier consists of a small movable scale adjacent to the main scale or limb, as it it called. The divisions of the vernier are either larger or shorter than those on the main scale. Thus if the main scale is divided into inches and tenths, then the vernier will have ten divisions equal to either nine-tenths of an inch or eleven-tenths of an inch. If the ten divisions of the vernier are equal to nine-tenths of an inch, then the vernier is said to be direct reading. In this case the smallest division on the venier is one one-hundredth of an inch shorter than the smallest division on the main scale, i. e., ten vernier divisions are one-tenth of an inch short, hence one vernier division is one-tenth of one-tenth, or one one-hundredth of an inch short.

In the accompanying figure the main scale is divided into inches and tenths. Ten vernier divisions are equal to nine-tenths of an inch. If the zeros of the two scales be placed together, the first division line of the vernier falls one one-hundredth of an inch short of the first, or one-tenth, division of the main scale. The second vernier division falls two one-hundredths of an inch short of the two-tenths limb division. Following this on through it is seen that the tenth vernier division falls ten one-hundredths short of the

ten limb divisions, or rather it coincides with the nine-tenths inch limb division.

Hence if the vernier be moved along until the first division coincides with the one-tenth limb division, the vernier zero will have moved one one-hundredth of an inch from the limb zero. If the second divisions coincide, the zeros will be two one-hundredths of an inch apart and so on. Suppose we wish to measure the length of the piece A. Place one end opposite the zero of the main scale, and opposite the other end of A place the zero of the vernier scale. The vernier zero is seen to lie between two and three-tenths and two and four-tenths inches. Now follow along the vernier scale until the division coinciding with a main scale division is reached. This is seen to be the sixth vernier division, and therefore the vernier zero is six one-hundredths of an inch beyond two and three-tenths inches and hence the piece A is two and thirty-six one-hundredths (2.36) of an inch in length.

As a rule to be remembered, it may be stated that **the value of the smallest division on the main scale divided by the number of divisions on the vernier scale gives the smallest reading that may be made with the vernier.**

The following rules for reading verniers will apply to any scale units:

First. Read the last subdivision of the main scale passed over by the zero of the vernier. Call this reading (a);

Second. Look along the vernier until a line is found which coincides with some line on the main scale. Read the number of this line from the scale of the vernier. Multiply this number by the value of the smallest reading of the vernier as determined above, and the result is the correct vernier reading. Call this reading (b);

Third. The sum of (a) and (b) is the value sought. Thus in the above example:

and $b = .06$ inch,

$a = 2.3$ inches;

hence $a + b = 2.36$ inches.

Verniers are sometimes made with ten divisions equal in length to eleven smallest main scale divisions. These are termed retrograde verniers for the reason that it is necessary to read back along the vernier scale to find the coinciding lines. Otherwise the principle of operation is the same as with the direct reading vernier, and the above rules apply to either.

In circular verniers the scales frequently read in degrees or half degrees, and the vernier then will have thirty divisions equal in length to twenty nine such half degree divisions. It will thus read one-thirtieth of one-half degree as the smallest reading, or one-sixtieth of a degree or one minute of arc.

N. A. S. E. BALL.

The committee of arrangements for the annual ball to be given under the auspices of California No. 1, and California, No. 3 of the National Association of Stationary Engineers, on April 2d, have about completed all preparations. The tickets will be 50c each. The Auditorium Annex will be tastefully decorated and ample provision has been made for refreshments. The committee consists of B. E. George, chairman; H. W. Noethig, secretary; Chas. Dick, treasurer; John Traynor, J. W. Maher, C. C. Elsasser, W. M. Jenkins, P. L. Ennor, J. W. Carter, J L. Davis and W. T. Bonney.

THE WATT-HOUR METER.

BY WM. M. SHEPARD AND ALLEN G. JONES.

CHAPTER III.

(Continued.)

Connections of Single Phase Meters.

Fig. 29 shows the diagram of connections for a single phase watt-hour meter when used on a single phase two wire circuit.

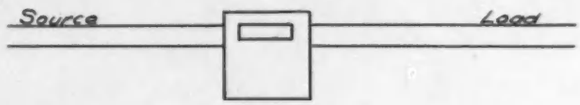


Fig. 29.

Fig. 30 shows the connections of two single phase meters connected so as to register the power flowing

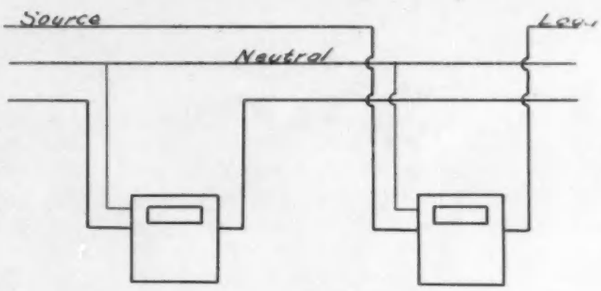


Fig. 30.

in a single phase three wire circuit, and Fig. 31 shows one three wire single phase meter connected for the same conditions. The three wire meter in effect is

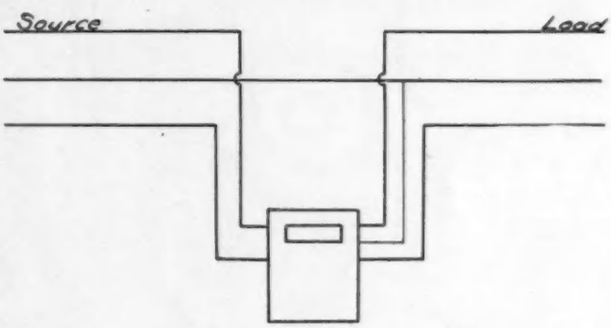


Fig. 31.

really two meters with but one disc and one potential coil, but with a current coil in each side of the line. The fact that the three wire meter has but one potential winding will cause an error in its registration if the voltage between each line and the neutral is not the same. The polyphase meter can also be used as a single phase three wire meter, and is not subject to the error just mentioned, but owing to its greater cost, it is seldom used for this purpose.

One single phase two wire meter can also be used to register the power flowing in a single phase three wire system by using it in connection with a special "three wire" current transformer. Such a transformer has two primary windings and one secondary winding. The two primary windings are connected respectively

in series with each side of the line, the current in the secondary being proportional to the vector sum of the currents in the two primaries. The connections of a single phase meter when used with such a transformer are shown in Fig. 32.

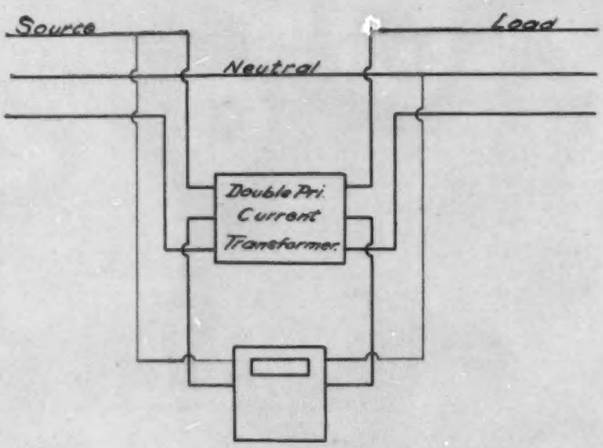


Fig. 32.

Single Phase Meters on Polyphase Circuits.

Two single phase meters may be used to register the power being supplied by either a two phase or a three phase system. For a two phase four wire system, one meter should be connected in each phase as shown in Fig. 33, and when so connected, each meter

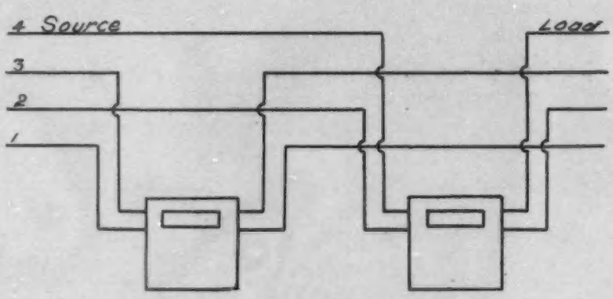


Fig. 33.

will register the power in its respective phase; the algebraic sum of the readings of the two meters will then be the total power supplied by the two phase system.

In the case of a three phase system, the two single phase meters should be connected as shown in

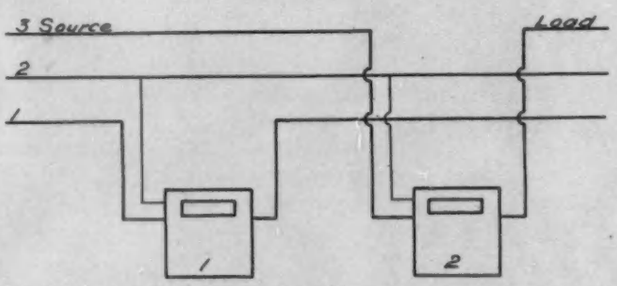


Fig. 34.

Fig. 34. The action of the two meters thus connected can best be explained by reference to the vector diagram.

Fig. 35, in which AC, CB and AB represent the voltages between the phases 2 and 1, 1 and 3, and 3 and 2 respectively; also let CO, BO and AO represent the currents in the phases 1, 3 and 2 respectively, for the condition of unity power factor, and C'O, B'O and A'O the currents for a power factor other than unity.

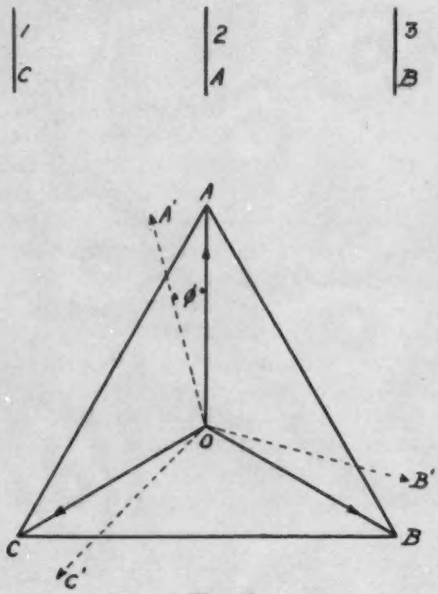


Fig. 35.

We will first consider the case of a balanced system. In this case let e represent the e.m.f. between a line and neutral, then $e = \frac{E}{\sqrt{3}}$, when E is the voltage between lines; also let I represent the current per phase in a balanced system. A three phase system may be considered as consisting of three single phase systems with the neutral as a common return; the voltages of each of the single phase systems being represented by e, and the current by I. The power in each single phase system will be = (e I) cos θ, where θ is the angle by which the current is displaced in phase from the voltage, (Fig. 35); the power in the three phase system will therefore be the sum of the power in the three equivalent single phase systems, or, numerically,

$$P = 3\,e\,I\cos\theta;\ \text{and since } e = \frac{E}{\sqrt{3}},$$

we have $P = \sqrt{3}\,E\,I\cos\theta$, which is the fundamental equation for the power flowing in a three phase system.

The two meters connected as shown in Fig. 34 will each have a current I flowing through it, and a voltage E impressed upon its potential winding. In meter No. 1, the current is represented by the line C'O (Fig. 35), and the voltage by CA; and in meter No. 2 the current is represented by B'O, and the voltage by AB; the current being represented as being out of phase by the angle θ. The angle OCA = angle OBA = 30 degrees, which is the angular displacement between the impressed voltage and the line current for unity power factor. For power factors other than unity, this angular displacement is equal to 30 degrees

plus or minus the angle θ, and as can be readily seen from the diagram it will be $(30° - \theta)$ for one meter and $(30° + \theta)$ for the other meter.

The power p', registered by one meter will therefore be

$p' = E\,I \cos (30° + \theta)$, and the power p'', registered by the other meter will be $p'' = E\,I \cos (30° - \theta)$, from which

$$p' + p'' = EI \cos (30° + \theta) + EI \cos (30° - \theta)$$
$$= EI\,[\cos (30° + \theta) + \cos (30° - \theta)]$$
$$= EI\,[2 \cos (30° \cos \theta)]$$ and since $\cos 30° = 1/2\sqrt{3}$,

we have

$p' + p'' = EI\sqrt{3} \cos \theta$, which, as shown above, is the equation for the power flowing in a three phase system. It is therefore seen that two single phase meters will register correctly the power in a balanced three phase system.

An unbalanced three phase system may be considered as consisting of a balanced system with the addition of an unbalancing component of either current, voltage or both. When using two single phase meters on an unbalanced three phase system, the unbalanced component will be taken care of as follows:

Suppose that in addition to the balanced current, there is a current flowing between the phases 2 and 3 (Fig. 35), or between 2 and 1; this current would flow either through meter No. 1 or meter No. 2, and as the meter through which it would flow has impressed upon it the voltage of the phases between which this current is flowing, the meter would register the power correctly. In the case of an unbalanced current passing between phases 3 and 1, such current would flow through both meters, and if this unbalanced current is in phase with the voltage BC, between phases 3 and 1, it will be 60° out of phase with the voltage impressed upon each meter, and as the cosine of 60° is 1/2, the correct amount of power will be registered, one-half being registered by each meter. If this current is not in phase with BC, it will be out of phase more than 60° in one meter, and less than 60° in the other meter; the correct amount of power will still be registered, but it will not still be equally divided between the two meters. The angle by which this unbalanced current will be out of phase in one meter will be $(60° + \theta)$, and in the other it will be $(60° - \theta)$, where θ is the angle of displacement between the unbalanced current and the voltage BC. The power registered by one meter will be $= E\,i \cos (60° + \theta)$, where i = the unbalanced current, and that registered by the other would be $= E\,i \cos (60° - \theta)$, and the total unbalanced power would be,

$$p = E\,i \cos (60° + \theta) + E\,i \cos (60° - \theta),$$
$$= E\,i\,(2 \cos 60° \cos \theta),$$ and since $\cos 60° = 1/2$,

we have $p = E\,i \cos \theta$, which shows that the power would be correctly registered in the case of an unbalanced current.

Unbalanced voltages would be taken care of in a similar manner. An unbalanced voltage across phases 1 and 2, or across 2 and 3, would directly affect the potential winding of one or the other of the single phase meters. An unbalancing of the voltage across phases 3 and 1 would affect both meters by distorting the voltage triangle so that the power transmitted would still be correctly registered.

Another method of connecting two single phase meters to register the power in a three phase system

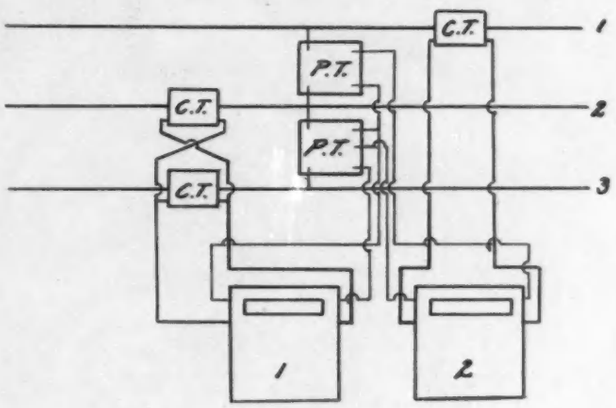


Fig. 36.

in conjunction with current and potential transformers is shown in Fig. 36; the relations of the currents and voltages being shown in the vector diagram,

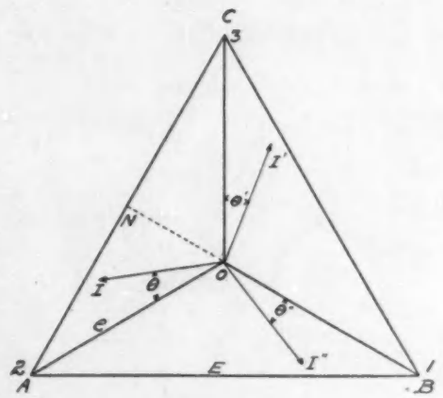


Fig. 37.

Fig. 37. Let I, I' and I'' represent the currents in the three legs of a three phase system; E being the voltage between lines and e the voltage between any line and neutral. Also let θ, θ', and θ'' represent the angles by which the currents are displaced from the position of unity power factor; we will assume the voltage to be balanced, since this makes the explanation somewhat simpler. The true power is $P = e\,I \cos \theta + e\,I' \cos \theta' + e\,I'' \cos \theta''$. Meter No. 1 has currents I and I' flowing through its winding (that is, the resultant of these currents), and the voltage, E, CA, impressed upon it; it is used with a multiplier of 1/2.

Meter No. 2 has the current I'' flowing through it, and the voltage Bn, impressed upon it; $Bn = (3/2)\,e$. Let P represent the total power, P' the power registered by meter No. 1 and P'' the power registered by meter No. 2,

$$P' = EI' \cos (30° - \theta') + EI \cos (30° + \theta).$$

$$P'' = \frac{3}{2}\,e\,I'' \cos \theta''.$$

$$P = \frac{P'}{2} + P''$$

$$= \frac{EI' \cos(30-\theta') + EI \cos(30+\theta)}{2} + \frac{3}{2} eI'' \cos\theta''$$

and $\cos(30^\circ - \theta') = \cos 30^\circ \cos\theta' + \sin 30^\circ \sin\theta'$
$\cos(30^\circ + \theta) = \cos 30^\circ \cos\theta - \sin 30^\circ \sin\theta$;

also, $\cos 30^\circ = \frac{\sqrt{3}}{2}$, $\sin 30^\circ = \frac{1}{2}$, and $e = \frac{E}{\sqrt{3}}$

whence $P = E\left[\frac{I\sqrt{3}}{2}\cos\theta - \frac{I \sin\theta}{2} + \frac{I'\sqrt{3}}{2}\cos\theta' + \frac{I'}{2}\sin\theta'\right]\frac{1}{2} + \frac{E\sqrt{3}}{2}\cos\theta'' I''$

$$= \frac{\sqrt{3}\,E}{4}(I\cos\theta + I'\cos\theta') + \frac{E}{4}(I'\sin\theta' - I\sin\theta) + \frac{E\sqrt{3}}{2}\cos\theta'' I''.$$

The vector sum of the currents in a three phase three wire system is zero, therefore $I''\cos\theta'' = I\cos(60-\theta) + I'\cos(60+\theta')$, reducing this we get $I'\sin\theta' - I\sin\theta = \frac{2}{\sqrt{3}}[\frac{1}{2}(I\cos\theta + I'\cos\theta') - I''\cos\theta'',]$ substituting this for $I'\sin\theta - I\sin\theta$ in the above and substituting $\sqrt{3}\,e$ for E, we derive,

$$P = \frac{3}{4}e(I\cos\theta + I'\cos\theta') + \frac{e}{2}\left(\frac{I}{2}\cos\theta + \frac{I'}{2}\cos\theta' - I''\cos\theta''\right) + \frac{3e}{2}I''\cos\theta''.$$

whence $P = e\,I\cos\theta + e\,I'\cos\theta' + e\,I''\cos\theta''$.

The particular feature of this connection is that it gives an indication of how well the system is balanced; if the system is perfectly balanced the two meters will register the same power, taking into consideration, of course, the multiplier of 1/2. This is true with the connection previously described and most often used, only when the power factor is unity.

If the system is perfectly balanced, either of the meters can be relied upon to record the total power, regardless of the value of the power factor, in which case the dials of meter No. 1 would be read without a multiplier, and meter No. 2 would have a dial multiplier of 2.

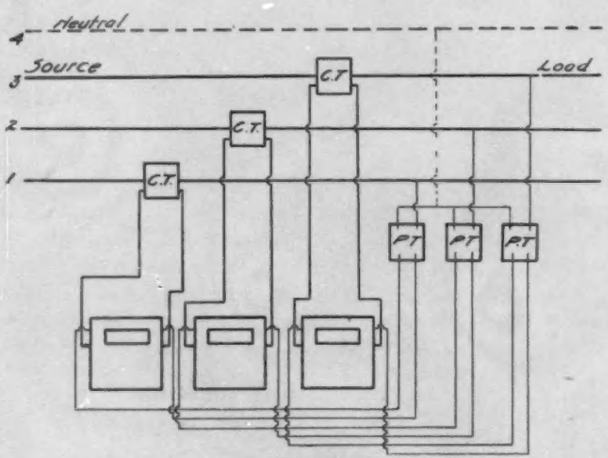


Fig. 38.

In Fig. 38 is shown the connections of three single phase meters for measuring the power in three phase, three and four wire systems. The three phase circuit is metered in this case simply as three single phase circuits, the current in each phase being the current in one of the single phase circuits, and the voltage of each single phase circuit being the voltage from the corresponding line to the neutral. The sum of the readings of the three meters will be the kilowatt-hours supplied by the three phase system.

The advantage of this connection for the three wire system is that the meters operate under better power factor conditions than with the usual two meter method. With this method the current and e.m.f. of each meter will be in phase when the power factor of the load being metered is unity, while with the two meter method the current and e.m.f. are 30° out of phase.

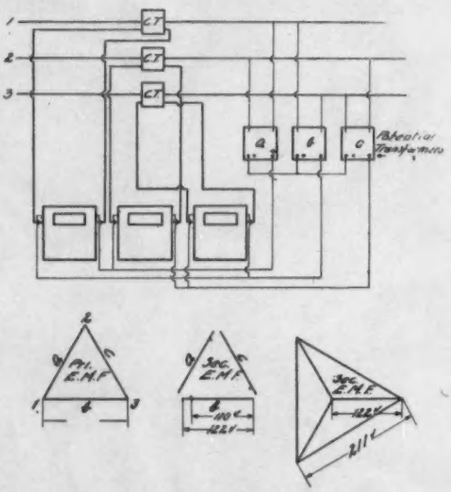


Fig. 38a.

Figure 38 (a) shows another method of connecting the potential transformers for measuring the power flowing in a three phase three wire system by means of three single phase meters. This connection, with certain primary voltages, permits the use of standard ratio potential transformers, otherwise the connection shown in Fig. 38 (a) will require ratios other than the standard. This method is especially applicable to 2300 volt circuits, the standard potential transformer used in this case would be rated 2200 volts primary, and 110/122 volts secondary, the higher secondary voltage (122) being used as is indicated in the figure. With a 2300 volt primary, a secondary voltage of approximately 220 volts would be obtained from the potential transformers, thereby permitting the use of standard 220 volt meters. When meters are used in this manner, a multiplying factor, $\frac{R \times R'}{3}$, is employed in obtaining the total reading, in which R = the ratio of the current transformers and R' = ratio of the potential transformers $(= \frac{2200}{122})$.

Determination of Power Factor by Means of Two Single Phase Meters.

The method of metering with two single phase meters on a balanced three phase system has an advantage over the polyphase meter when it is desired

to obtain the average power factor of the load, which can be done by applying the following formula:

$$\text{Average Power Factor} = \frac{P' + P''}{2\sqrt{(P')^2 - (P' \times P'') + (P'')^2}}$$

where P′ and P″ represent the readings of the two single phase meters. The deduction of this formula is as follows: In the vector diagram, Fig. 38 (b) AB,

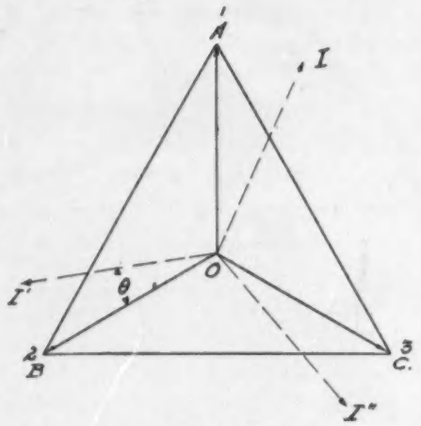


Fig. 38b.

AC and BC represent the voltages between the phases of a three phase circuit, and OI, OI′ and OI″ represent the currents in the legs 1, 2 and 3 respectively, and which are displaced from the position of unity power factor by the angle θ. Now suppose that the current coil of meter No. 1 is connected in leg No. 2, and that its potential coil is connected across AB; also that the current coil of meter No. 2 is connected in leg No. 3 and its potential coil across AC. Then the power, P′, being registered by meter No. 1 will be = AB. OI′ cos ϕ, where ϕ is the angle between AB and OI′ = (30° + θ), θ being the angle of current displacement. The angle OBA is of course 30°. Denoting the voltage AB by E, and the current OI′ by I, we have P′ = EI cos (30 + θ) and similarly, the power being registered by meter No. 2 will be P″ = EI cos (30 − θ), (assuming the system to be balanced). Then by trigonometry we have,

$$\cos(30 + \theta) = \cos 30 \cos\theta - \sin 30 \sin\theta$$
$$\cos(30 - \theta) = \cos 30 \cos\theta + \sin 30 \sin\theta$$

But $\cos 30° = 1/2\sqrt{3}$, and $\sin 30° = 1/2$,

Therefore $\cos(30 + \theta) = 1/2\sqrt{3}\cos\theta - 1/2 \sin\theta$

and $\cos(30 - \theta) = 1/2\sqrt{3}\cos\theta + 1/2 \sin\theta$

Substituting these values in the above equations for P′ and P″ we have:

$$P' = EI\left(\tfrac{1}{2}\sqrt{3}\cos\theta - \tfrac{1}{2}\sin\theta\right), \text{ hence}$$

$$EI = \frac{P'}{\left(\tfrac{1}{2}\sqrt{3}\cos\theta - \tfrac{1}{2}\sin\theta\right)}$$

$$P'' = EI\left(\tfrac{1}{2}\sqrt{3}\cos\theta + \tfrac{1}{2}\sin\theta\right), \text{ hence}$$

$$EI = \frac{P''}{\left(\tfrac{1}{2}\sqrt{3}\cos\theta + \tfrac{1}{2}\sin\theta\right)} \text{ or since } EI = EI,$$

we have

$$\frac{P'}{\tfrac{1}{2}\sqrt{3}\cos\theta - \tfrac{1}{2}\sin\theta} = \frac{P''}{\tfrac{1}{2}\sqrt{3}\cos\theta + \tfrac{1}{2}\sin\theta}$$

By trigonometry, $\sin\theta = \sqrt{1 - \cos^2\theta}$, and substituting this value

$$\sqrt{3}\,P'\cos\theta + P'\sqrt{1-\cos^2\theta} = P''\sqrt{3}\cos\theta - P''\sqrt{1-\cos^2\theta},\ \sqrt{1-\cos^2\theta}\,(P' + P'')$$
$$= (P'' - P')\sqrt{3}\cos\theta.$$

Squaring and transposing, we have,

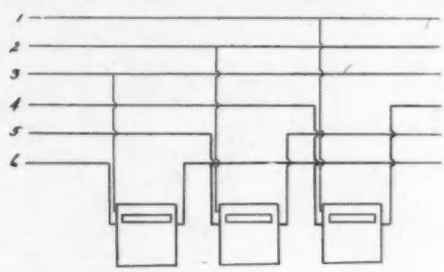
$$\cos^2\theta\,[\,4(P')^2 - 4P'P'' + 4(P'')^2\,] = (P' + P'')^2,$$

Whence

$$\cos\theta = \frac{P' + P''}{2\sqrt{(P')^2 - P'P'' + (P'')^2}} = \text{average power factor}$$

The true instantaneous power factor can also be determined by this method, using two indicating wattmeters.

Single Phase Meters for Six Phase Circuits.



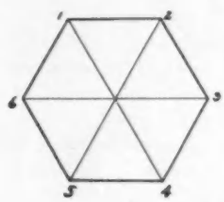


Fig. 39.

Three single phase meters can be used for measuring the power in a six phase system by connecting them as shown in Fig. 39.

(To be continued.)

PROBLEMS DISCUSSED BY CALIFORNIA NO 3. N. A. S. E.

BOILER REPAIRING—How could a bag in a boiler be repaired without putting on a patch?

Heat the bagged surface with a portable forge (by removing the legs from an ordinary hand forge it can usually be placed directly under the boiler)—and when the plate is red it can be hammered back to normal position. A bag has been pulled back, when hot, by putting a jaw-brace inside the boiler and then drilling a hole in the center of the bag so that a bolt can be used to pull the sheet back into line. If the bag is very bad, however, the best practice would be to put a patch on after cutting out the stretched portion of the sheet. This would insure the job while a bag hammered or pulled back into line may leave the metal weakened.

PORTLAND SECTION A. I. E. E.

The next regular meeting of the Portland Section will be held in the Assembly Hall of the Electric Bldg., Tuesday evening, March 22, 1910 at 8 P. M. A paper will be presented by Mr. O. B. Coldwell on Efficiency Tests of a Water Wheel Unit.

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Changes of advertising copy should reach this office *ten days in advance of date of issue.* New advertisements will be accepted up to noon of Monday dated Saturday of the same week. Where proof is to be returned for approval, Eastern advertisers should mail copy at least thirty days in advance of date of issue.

Entered as second-class matter at the San Francisco Post Office as "The Electrical Journal," July 1895.
Entry changed to "The Journal of Electricity," September, 1895.
Entry changed to "The Journal of Electricity, Power and Gas," August 15, 1899.
Entry changed May 1, 1906, to "The Journal of Electricity, Power and Gas," Weekly.

FOUNDED 1887 AS THE
PACIFIC LUMBERMAN, CONTRACTOR AND ELECTRICIAN

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Licensing Steam Engineers

At first thought it seems unjust to deny a man the privilege of running a steam plant because he cannot answer a list of complex conundrums propounded by a board of examiners. The engineering magazines abound with examples of absurd and insidious catch questions that have been skillfully contrived as traps to the unwary. Even at the best, an engineer enters an examination with no little trepidation and fear of its outcome. He is placed at much the same disadvantage as is a woman in curl papers. Nervousness throws him off his guard, and he fails to pass a creditable examination, whereas his less competent, but more self possessed, competitor obtains a satisfactory rating.

The fault lies not with the engineer, but with the system . The inadequacy of the written test is well known and many more or less successful attempts have been made to find a suitable substitute, or at least a supplement. With proper preparation, however, a capable engineer seldom fails in a fair test. Unfortunately favoritism is frequently charged, especially in municipal examining boards which may be closely linked with local politics. Some method that will remove the examiners from suspicion of these corrupting influences is greatly to be desired. We believe that no charge of intentional dishonesty has ever been proven against a member of one of these boards. Nevertheless, it is no more than right that they should be so placed that they may possess those attributes demanded of Caeser's wife.

Experience has shown that equitable administration of a State license law is the most satisfactory solution of this problem yet devised. Some other more acceptable means is a possibility of the future, but until its excellence has been demonstrated, the State license law should receive the active support of every broad-minded engineer. Most of the opposition to it comes from labor leaders, who lose sight of the fact that its prime purpose is not to specify who are competent engineers, but to protect the public. A boiler explosion is disastrous, not only to the engineer in charge, but also to all persons in the vicinity, and every precaution is taken to prevent such an accident. We find that some of the examining boards confine their questions largely to boilers and their auxiliaries, as they are the most prolific source of accidents in power plants.

Steam is like a poison in that it is dangerous in unskilled hands. Public safety requires the licensing of the druggist who dispenses the poison and likewise of the engineer who operates the steam plant. We would suggest that even the firemen and the water tender should be properly impressed with the life hazard that attends their work and be compelled to occasionally show their proficiency.

PERSONALS.

W. W. Briggs has been appointed Jovian Statesman for Northern California.

Al Palmer of the Philips Insulated Wire Company of Pawtucket, R. I., is visiting San Francisco.

W. J. Davis, Jr., Pacific Coast engineer of the General Electric Company, is making an Eastern trip.

H. B. Squires of Otis & Squires of San Francisco is in the Northwest with H. Krantz of Brooklyn, N. Y.

John Coffey Hays, manager of the Mount Whitney Power Company of Visalia, was a recent San Francisco visitor.

O. I. Cheney, chief electrician at the Mare Island Navy Yard, was a visitor to San Francisco during the past week.

H. V. Gates, president of the Klamath Falls Light and Water Company, has returned to Hillsboro, Ore., from a trip to Mexico.

E. M. Scribner has been appointed Western sales manager of the Arrow Electric Company of Hartford, Conn. with headquarters in Chicago.

Arnold Pfau, engineer with the Allis-Chalmers Company, is in San Francisco during the course of a Pacific Coast tour, after which he will return to Milwaukee.

K .G. Dunn, engineer with Hunt, Mirk & Co., Coast representatives of the Westinghouse Machine Company, has returned from a business tour of the Pacific Northwest.

H. H. Noble, president of the Northern California Power Company, was recently slightly injured by being thrown from a horse while inspecting power properties near Redding, Cal.

A. W. Vinson, Pacific Coast engineer for the Cutler-Hammer Manufacturing Company, recently returned to San Francisco from a meeting of the company's engineers at Milwaukee.

C. A. Greenidge, recently manager of the electric department of the Utica Gas and Electric Company, has joined the staff of J. G. White & Co. of New York as engineer of the operating department.

A. E. Hursh recently resigned his position as manager for the San Joaquin Light and Power Company at Selma, Cal., and will in future be in charge of the Gas and Power Company's plant at Coalinga.

Thomas Mirk of Hunt, Mirk & Co. returned last week from Los Angeles after spending considerable time in the South in connection with the closing of some good contracts for Westinghouse-Parsons turbo-generators.

Frank McGovern of the Archer-McGovern Company of New York, which is one of the largest second-hand machinery dealers in the United States, is in San Francisco in connection with the purchase of some of the discarded 25-cycle electrical apparatus from the United Railroads.

Pacific Coast engineers recently elected associate members of the American Institute of Electrical Engineers include T. F. Arnott, quartermaster electrician, Puget Sound Navy Yard, Charleston, Wash.; C. E. Christiansen, electrical engineer Toledo Light, Power and Manufacturing Company, Toledo, Ore.; W. T. Drake, instructor in Polytechnic College of Engineering, Oakland, Cal.; W. S. Johnson, assistant in electrical engineering department, Pacific Light and Power Company, Los Angeles, Cal.; W. D. A. Peaslee, student Stanford University, Stanford, Cal.; L. M. Perrin, draughtsman Southern Pacific Company San Francisco; H. S. Shedd, superintendent of operation, Great Western Power Company, Oakland, Cal.; G. H. Stockbridge, assistant superintendent of transmission, Southern California Edison Company, Los Angeles, Cal.; C. G. Worthington, consulting electrical engineer, Vancouver, B. C.

MEETING OF PACIFIC COAST GAS ASSOCIATION.

The Pacific Coast Gas Association calls advance attention to the fact that the eighteenth annual convention will convene at Los Angeles, Cal., September 20th, 1910. President W. B. Cline has already announced that the Los Angeles Gas & Electric Corporation, the Pacific Light & Power Company and Southern California Edison Company will join in entertaining the members attending the Convention.

SAN FRANCISCO JOVIANS MEET.

In response to the call of W. W. Briggs, the newly appointed Statesman for Northern California, an enthusiastic meeting of the Sons of Jove was held at Tait's cafe on Friday evening, March 18, 1910. This was the first of a number of "Jovian blowouts" yet to come, and its success augurs well for a revival of interest among local electrical men.

TRADE NOTES.

Otis & Squires of San Francisco have been appointed agents in California, Arizona and Nevada for the Durant Electric Company of Chicago, Ill., makers of rubber covered iron telephone drop wire.

Hunt, Mirk & Co. have sold the Union Lumber Company a 1,000 kw. Westinghouse-Parsons turbo-generator set, together with switchboard, exciter and condensers. This additional equipment will be installed in the company's plant at Fort Bragg, Cal.

The Western Electric Co. has sold the Philippine Telephone & Telegraph Co., for use in the Manila office, 340 additional multiple. Two complete train-dispatching telephone outfits have been sold to the Southern Pacific Company, also one set of messenger equipment.

The General Electric Company reports the following sales: To Lidgerwood Manufacturing Co., three I. T. C. 5017 300-h.p. 575 r.p.m. 440-v. hoist motors, with type M control. Four I. T. C. 5013 52-h.p. 565 r.p.m. 440-v. hoist motors, with T. 10 controllers, for use on the construction of the addition to the Great Western Power Co.'s dam at Big Bend.

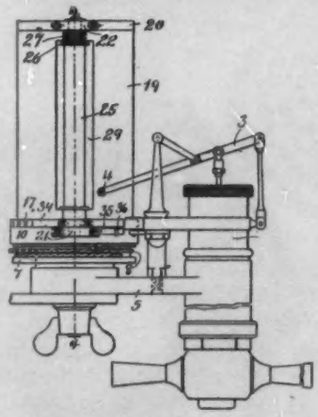
Hunt, Mirk & Co. have closed a contract with the Municipal Light and Power Company of San Francisco for an additional Westinghouse-Parsons turbo-generator having a capacity of 1,000 kw. for an extension of the existing electric power plant in the Claus Spreckels building annex on Stevenson street. The same firm will also furnish the additional Stirling boilers, condensers and cooling plant.

The 1500-k.w., 3-phase generator, which the Allis-Chalmers Company recently sold to the interests represented by W. H. Metson, is to be installed in a new power house near Bodie, Mono County, Cal., (instead of on the Nevada-California Power Company's Bishop Creek development). The generator will be direct-conected to a turbine water wheel operating under a head of about 350 feet. Current will be transmitted to Bodie and to mines in Nevada. The Fort Wayne Electric Works will supply the switchboard for the new plant and also some transformers.

The Pacific Light and Power Company of Los Angeles has just ordered from the General Electric Company two 12,000 kw. Curtis vertical steam turbine generators—rated A. T. B. 8, 12,000 kw., 750 r.p.m., 9,000 v.—together with one horizontal Curtis turbine exciter set, rated C. C. 4, 100 kw., 2,400 r.p.m., 250 v. These machines are to be installed in the company's present Redondo plant, in which there are now installed three 5,000 kw. engine-driven units consisting of General Electric generators direct connected to McIntosh & Seymour engines. The new turbines will be installed in one end of the building in the space now occupied by circulating pumps and auxiliaries.

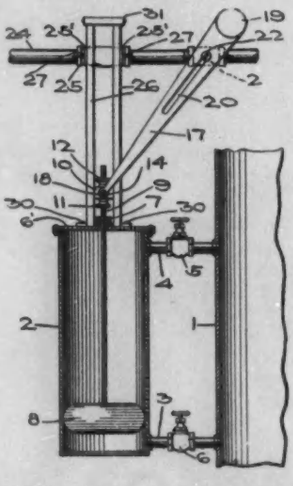
PATENTS

951,131. Continuous-Card Indicator. Amos P. Kinney, Quincy, Mass., assignor to American Steam Gauge and Valve Manufacturing Company. An indicator comprising a card-carrying drum, a pressure-actuated marker arranged to reciprocate beside said drum and parallel to the axis theeof,



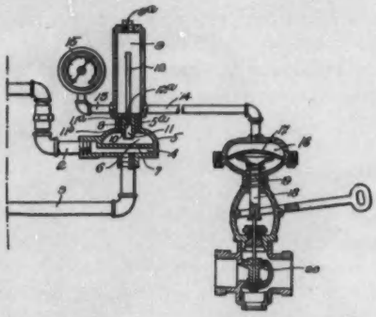
means for oscillating said drum in synchronism with the strokes of the engine being tested, and a stationary feed pawl arranged to engage and arrest said drum during a portion of the return oscillation of the drum, to produce a forward feed thereof and of the card relatively to the marker.

950,533. Automatic Boiler-Feeder. Charles J. Lindberg, Malmo, Minn. In a device of the character described, the combination with a cylinder, of a float, a stem extending from said float and projecting beyond one end of said



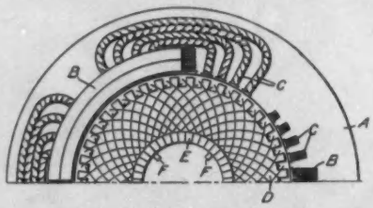
cylinder, an operating lever, one end carried pivotally by said stem, the other end free, a slot being centrally formed on said operating lever, a throttle valve, the stem of which passes through said slot, and adapted to be turned by rocking of said lever.

950,493. Feed-Water Regulator. Fred H. Plouff, Boston, Mass. In a feed-water regulator, in combination, a water and steam chamber adapted to be connected with the water and steam spaces of a boiler, a liquid chamber separated from said water and steam chamber by a heat-transferring partition, a reservoir with a passage leading therefrom to said liquid chamber, a pipe mounted in said passage and extending therefrom into said reservoir and furnished, preferably near its lower end, with apertures leading into said reservoir and a conduit leading from said reservoir to a



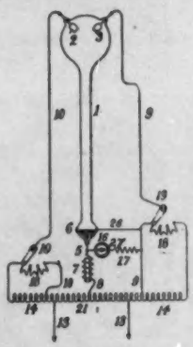
chamber adapted by suitable mechanism to control a water supply for said boiler; substantially as described.

951,357. Single-Phase Commutator-Motor. Ernst F. W. Alexanderson, Schnectady, N. Y., assignor to General Electric Company. An alternating current motor, comprising a stator, an exciting winding thereon, an inducing winding distributed in slots on the faces of the poles of the exciting



winding producing a relatively excessive magnetizing effect at the pole tips, an armature having the coils of its winding of a pitch approximately equal to the circumferential width of the pole faces of the exciting winding, a commutator and brushes for the armature, and connections for including the armature in a local closed circuit.

951,085. Single-Phase Gas or Vapor Electric Device. Percy H. Thomas, Pittsburg, Pa., assignor to Cooper Hewitt Electric Company. In a system of electrical distribution, a gas or vapor electric apparatus provided with a starting band, two or more positive electrodes and a negative electrode, a source of single phase alternating current connected



with the said apparatus, a choke coil interposed at a suitable point in the system, a starting device capable of creating a critical strain within the apparatus, and means for applying to the apparatus a momentary initial excess of potential, the current produced by the extra potential being adapted to pass through the choke coil.

INDUSTRIAL

THE GOEHST INSULATION CUTTER.

Te accompaning pictures show the method of using the Goehst insulation cutter, which is being placed on the market by Mathias, Klein & Sons of Chicago, Ill. By the use of this cutting plier it is claimed that one man can do better work in less time than three men working with knives.

When cutting insulation for joints the wire is held in the V-shaped cutters and the jaws pressed together so as to cut the insulation as shown in Fig. 1. The insulation is then pressed off with the flat nose of the pliers, as shown in Fig. 2.

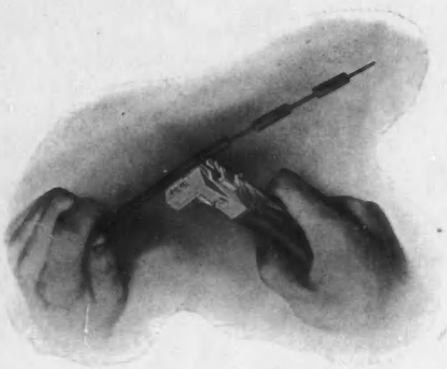


Fig. 2.

Fig. 1.

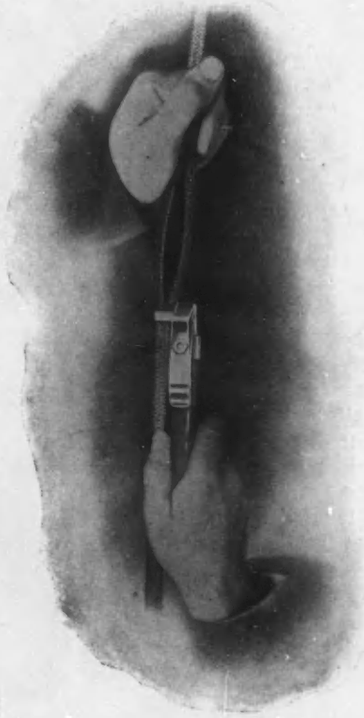


Fig. 3.

Fig. 3 shows the method of slitting Duplex wire. By inserting the jaws in the wire and drawing the pliers toward the operator, the wire is cut rapidly and clean, leaving the two strands perfect with the braid removed.

ANNOUNCEMENTS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

On Tuesday evening, March 8th, there was a meeting of the American Society of Mechanical Engineers, the American Institute of Electrical Engineers co-operating, in the Engineering Societies Building, New York, with a paper by H. G. Stott, Mem. Am. Soc. M. E., superintendent of motive power of the Interborough Rapid Transit Company, New York, and R. J. S. Pigott on "Tests of a 15,000 kw. Steam Engine Turbine Unit." The paper related to the installation of low pressure turbines at the Fifty-ninth street station of the Interborough Rapid Transit Company, New York, and presented a discussion of the most important development in steam engineering since the commercial introduction of the steam turbine.

The turbines operate on exhaust steam from the engines, with which the station was originally equipped. These are double compound engines of the Manhattan type with horizontal high-pressure and vertical low-pressure cylinders. The generators of the engines are capable of safely carrying a load of 8000 kw. each, but the normal economic ratings of the engines is only 5000 kw. The low-pressure turbines, three of which are in process of installation, were added primarily to increase the output of the station. By the addition of the turbines the engines can be run economically up to the full capacity of their generators and there is besides the current from the turbo-generators, making a total output of 15,000 kw. per combined unit, or nearly double the previous maximum output; and with an average improvement in the economy of 25 per cent (between the limits of 7000 kw. and 15,000 kw.) over the results obtained by the engine units alone.

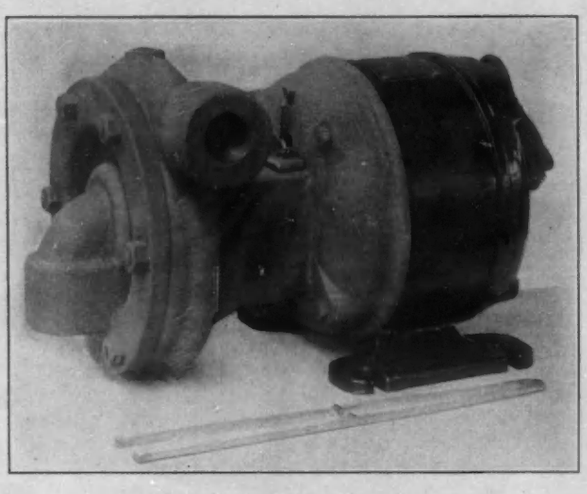
Boston Meeting, March 11, 1910.

The monthly meeting of the American Society of Mechanical Engineers in Boston was held Friday evening, March 11th, in the auditorium of the Edison Electric Illuminating Company. The Boston Society of Civil Engineers and the Boston section of the American Institute of Electrical Engineers co-operated in the meeting. The paper was by Mr. M. W. Alexander, Mem. Am. Soc. M. E., who has been so long identified with the educational work and the training of the apprentices at the works of the General Electric Company, West Lynn, Mass. The subject of the paper is "The Training of Men—A Necessary Part of the Modern Factory System."

ELECTRIC PUMPS FOR HOUSEHOLD WATER SUPPLY.

In that rapidly enlarging class of country houses and isolated homes where electrical power is available the dependency for water supply need no longer rest on the unreliable and expensive operation of windmills and gasoline engines. Theoretically cheap as these agents are supposed to be, the one involves a large first cost with a service as little dependable as the wind which serves it, while the other requires the attention of a trained mechanic to supervise the complicated engine, to say nothing of the explosive nature of the fuel employed, and the dangers of ignorance in its operation.

But the electric motor driven pump for house service, once installed, becomes a subject removed from the mind of the householder. It can be started and stopped by throwing a switch. An automatic cut-off can also be provided which will stop the pump when the water level in the roof tank has reached a predetermined height, starting the motor again before the storage supply has run low.



Electric Motor Driven Volute Pump.

As shown in the accompanying illustration, the motor driven volute pump for this class of service is compact and solidly constructed. The motor is of the Westinghouse alternating current induction type, in which all special or delicate parts have been eliminated, resulting in a thoroughly dependable, sturdy, completely enclosed electrical machine, which transmits its output through a shaft directly to the impeller blades rotating in the cast iron case seen at the left. This volute pump is designed to deliver 800 to 1000 gallons per hour against heads up to 50 feet, when running at 2800 to 3300 revolutions per minute. The intake is shown at the left, entering at the center of the pump case, while the discharge orifice is the hole, threaded for a one-inch pipe, seen opening toward the observer. There are, of course, no valves in this pump, and packings, pistons, etc., are also eliminated. The pump, which is arranged to be bolted onto the motor frame, making a compact unit, was designed and built by Henry R. Worthington, Harrison, N. J. Motors for this class of duty are built by the Westinghouse Electric and Manufacturing Company, Pittsburg, Pa.

CATALOGUE EXPERIENCE MEETING OF TECHNICAL PUBLICITY ASSOCIATION.

The Technical Publicity Association held a well attended meeting on Thursday evening, February 10th, in the galleries of the National Arts Club, 14 Gramercy Park, New York. It was in the nature of an experience meeting on the subject of "Catalogues." An interesting and prolonged discussion, participated in by many of the advertising managers representing some of the most prominent of the technical manufacturing concerns and by representatives of publishing and paper firms, made the session a profitable one.

Considerable sentiment in favor of adopting standard sizes for commercial literature of this sort was found at the meeting. Many complained of the uneveness and lack of system among numerous catalogues, making them difficult to file.

An interesting paper by Martin P. Rice, head of the publication bureau of the General Electric Co., at Schenectady, N. Y., was read to the edification of those present Many attractive specimens of current catalogues were exhibited by the speaker and also by other members of the T. P. A.

J. George Frederick, editor of Printers Ink, dwelt on the logical relation of catalogues to an advertising campaign and spoke in favor of giving wider publicity to the catalogue to increase its distribution. Mere listing of goods and prices, he declared, should come after an impression has been made upon the reader by the catalogue.

Leroy Fairman, editor of Advertising & Selling, advocated the importance of making things perfectly plain in literature of this sort. "There is danger," he said, "in assuming that people who read catalogues know more than they really do know."

A. P. Waterman, advertising manager of the Holtzer-Cabot Electric Co., brought to the attention of the members a special cover for catalogues. This is in the form of a binder for loose leaf sheets, or sections of sheets, held together by fasteners; the back of binder folded so that it will expand to accommodate a great number of additional leaves.

C. R. Lippmann, advertising manager of the Genuine Bangor Slate Co., stated that certain engineering and architectural societies have adopted as standard for catalogues, size 5x8 inches. This is a convenient pocket size.

Vechten Waring stated that any book ¼ inches thick or thicker should be lettered on the backbone for easy finding. Referring to juxtaposition of cuts and reading matter he thought it far better advertising policy to say underneath a cut what it is, rather than designate it by the letter "A," "B" or "C." Translate sectional drawings into perspective drawings for easy reading and understanding. A title alone on title page is poor business. Abundant room is there for some strong selling argument.

F. F. Coleman mentioned an interesting experience in connection with the filing of catalogues which varied in size from 3x5 inches to 15x24 inches and various intermediate sizes. He advocated catalogue sizes 6x9 and 9x12 and that catalogues intended to be filed away for reference should be made of uniform size.

F. E. Dayton of Rodgers & Co., said that 9x12 inch size has been adopted by Master Car Builders' Association and that books which are to be kept for a long time should be bound on the long dimension.

Hal Marchbanks of the Hill Print shop, spoke in favor of simplicity in cataloging and presenting a technical product.

Chairman H. M. Davis, of the committee the proposed Uniform Advertising Contract, reported that the final draft of the contract which had been discussed at several of the previous monthly meetings, had been adopted by the members of the T. P. A. without a dissenting vote. Forty-eight votes, representing thirty-seven companies, were received.

A number of new members were admitted into the Association. The T. P. A. has enjoyed a steady growth in membership and influence. At the next monthly open meeting and dinner to be held Thursday, March 10th, at the National Arts Club, a lively discussion on the question of the proposed increase in second class mail matter is expected.

NEWS NOTES

FINANCIAL.

SPOKANE, WASH.—The City sinking fund committee awarded the sale of the Spokane waterworks bonds issue of $400,000 to N. W. Halsey & Co. of New York for $410,280.

DRAIN, ORE.—$15,000 in water bonds and $5,000 in sewer bonds have been voted. The former carried by a vote of 40 to 4 and the latter by a vote of 41 to 7. $6,000 of the money received will be tendered to the Drain Water Company for its plant now in operation.

COUER D'ALENE, IDA.—The Council has announced that a resolution be prepared authorizing an election in 40 days on an issue of bonds aggregating $167,000 for the purchase of the city waterworks, of auto fire fighting apparatus and for grading in three improvement districts.

SAN FRANCISCO.—The Supervisors have passed to print an ordinance by which the Mayor was empowered to enter into a contract with the Tuolumne Water Supply Company for the purchase for $400,000 of lands, water rights and all properties in the county of Tuolumne in Tuolumne in connection with the Lake Eleanor water supply for the city of San Francisco, and also to sign an option with the same company for $600,000 for the purchase of the so-called Cherry Creek lands and water rights.

LOS ANGELES, CAL.—The City Council has passed an ordinance calling for an election to be held in this city April 18th, submitting to the voters the proposition of incurring a debt of $3,000,000 for constructing docks, wharves, warehouses within the city; also for improving and constructing streets and highways to navigable waters; constructing and maintaining canals and waterways to navigable waters; also $3,500,000 for acquiring and constructing a municipal improvement, as follows: Works for generating and distributing electricity for supplying light, heat and power; including acquisition of lands, water rights, machinery, apparatus, and construction of electric generating works, distributing line, etc.; $2,000,000 will be expended on docks and wharves, streets, etc., in what is known as the outer harbor at San Pedro, and $1,000,000 on wharves, docks, warehouses, etc. in what is known as the inner harbor at San Pedro.

INCORPORATIONS.

WENATCHEE, WASH.—The Entiat Light and Power Company has been incorporated by C. A. Harris of Wenatchee.

OLYMPIA, WASH.—The Wenas Electric Power Line of North Yakima has been incorporated with a capital stock of $15,000 by Stephen D. Saunders, Peter C. Mann, M. B. Miles, Lewis J. Anderson and E. G. Towsan.

NEW WESTMINSTER, B. C.—The Stewart-Portland Canal, Power, Light and Water Company has been incorporated with a capital of $250,000. The object of the company is to supply the townsite of Stewart and vicinity with water, gas and power.

BRAWLEY, CAL.—The Westmoreland Water Company has been incorporated. The directors are H. C. Oakley, Peter Hovley, Philo Jones, G. T. Wellcome and G. B. McWilliams. The object of the company is to handle the domestic water system of the new town.

SAN FRANCISCO.—Articles of incorporation have been filed in this city and in Sacramento of the City and Suburban Water Company, capitalized at $28,000,000, included among the purposes of which is the supplying of domestic water to counties, cities, townships and villages throughout the State of California. The directors of the company are R. Rothschild, G. Cohen, F. Kaiser, J. Reid, J. Stewart, W. Fisher and A. Greene, all of whom reside in San Francisco.

TRANSMISSION.

TACOMA, WASH.—The contract to construct the first unit of the city's Nisqually power plant at Le Grande on the Nisqually river, 30 miles from Tacoma, went to Wright, Sweeney & Cummings for their bid of $655,225.

SPOKANE, WASH.—An application has been filed for a power site on the Kettle river, near Orient, by H. L. Moody of this city and J. L. Leeper of Orient. The site will be developed to furnish electricity for municipal users.

MEDFORD, ORE.—The Condor Light and Power Company, of which Dr. C. R. Ray is manager, has been bought by the Byllesby Company of Chicago. This firm operates several light and power plants and will expend over $250,000 this spring for improvements.

CELILO, ORE.—E. G. Ammie, contracting engineer, Beck building, Portland, has been employed by the Celilo Milling and Power Company (J. W. Griesse, Board of Trade, and C. L. Daggett) to design a power plant on the Columbia river at Celilo Falls to develop from 15,000 to 20,000 horsepower.

LOS ANGELES, CAL.—C. J. Curtis, president of the Los Angeles Dock and Terminal Company, announces the immediate building of a $2,000,000 power plant at Long Beach by the Edison Electric Company. The plant will be a steam generating one and have 30,000 horsepower.

TRANSPORTATION.

SANTA ROSA.—It is reported that the Petaluma and Santa Rosa Railroad will shortly be extended to Guerneville.

SACRAMENTO, CAL.—Sealed bids have been received by the Board of Trustees for the sale of a franchise to construct, maintain and operate a street railway in the city of Sacramento, Cal.

SANTA BARBARA, CAL.—The City Council has passed an ordinance granting to the Santa Barbara Consolidated Company a street railway franchise for a term of 25 years for the construction and maintenance of an electric street railway in this city.

SACRAMENTO, CAL.—An agreement has practically been reached between the Northern Electric Railroad Company, interested property owners and D. W. Carmichael whereby the electric line will build a branch from a point a little west of Ben Ali, on the other side of the American river, into Fair Oaks.

LOS ANGELES, CAL.—The Pacific Electric Redondo line and the Los Angeles Railway will in the near future erect a plant for the building of all the electric cars for the use of the allied Huntington interests in Southern California. This plant will be in Los Angeles and will be, when completed, in a position to build and assemble cars faster than they can be built and delivered by Eastern concerns.

LOS ANGELES, CAL.—The City Council has passed an ordinance granting to Edwards & Wildey the right to construct and for a period of 21 years to operate and maintain a double-track electric street railway upon a portion of a street commencing at the intersection of Heliotrope drive and Melrose avenue, thence westerly over and along Melrose avenue to Normandie street.

NEW WESTMINSTER, B. C.—The British Columbia Electric Railway Company has awarded a contract to the International Contract Company, Central building, Seattle, for the construction of two steel towers 190 feet in height to carry the high potential wires across the Fraser river. The steel has been ordered from the Canada Foundry Company of Toronto.

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43 Exchange Place, New York City

COLFAX, WASH.—The Spokane Inland Electric Railway estimates its loss by floods between this place and Steptoe at $100,000 including five bridges, five miles of track and depot.

CARBON, MONT.—The Carbon Commercial Club has voted a bonus of $5,000 to the Eastern Montana Electric Railway Company of Billings to secure an electric line for this city.

SANTA ANA.—The Board of Supervisors has received a petition from the Southern California Edison Electric Company for a franchise for all power lines in Orange county for which franchises are not already held.

SUISUN, CAL.—An ordinance has been passed granting to the Vallejo and Northern Railroad Company a franchise to construct, lay, maintain and operate a standard gauge electric railroad over, up and along streets and public highways in the town of Suisun.

SAN FRANCISCO.—The Public Utilities Committee of the Supervisors has agreed to recommend an extension of forty-five days to enable the United Railroads to install the required type of fenders on their cars. What is proposed is to recommend the rescinding of the present ordinance and the enactment of a substitute virtually identical in its provisions, except that it will not go into effect until April 30th, the present bill being effective on the 13th inst. This determination was reached because members of the committee were unwilling to accept the small fender of new pattern which Manager Black lately experimented with for their benefit. Having determined to insist on the use of the large projecting "Eclipse" type of fender, the members of the committee were willing to allow the company more time to install them.

ILLUMINATION.

CENTRALIA, WASH.—The petition of the J. A. Veness Lumber Company for the right to erect and maintain an electric light pole along certain county roads for a term of 25 years has been approved by the Board.

SALINAS, CAL.—The Trafton coal mine, 20 miles east of King City, in San Benito county, has been sold to the Western Consolidated Coal, Gas and Electric Company, with headquarters in San Francisco. The consideration is said to be $56,000, partly paid in cash.

CENTRALIA, WASH.—The Board of County Commissioners has granted the Centralia and Chehalis Gas Company the right to lay gas pipes underground along the east county road between Centralia and Chehalis to supply Centralia and Chehalis with gas, which will be manufactured at the plant now being built near Coal Creek.

SAN BERNARDINO, CAL.—A contract for the construction of a gas plant for the San Bernardino Gas Company merger organization of this valley has been let to the Stacy Manufacturing Company of Cincinnati. The plant, which will be erected at Colton, will have a capacity of 2,000,000 cubic feet of gas every 24 hours. The contract price is $132,500.

MONROVIA, CAL.—The Piedmont Company, said to be controlled by local capitalists, has purchased the Monrovia gas plant and distributing system formerly owned by the Edison Company. The new corporation will take possession on April 1st. The Piedmont Company plans to build here a central generating plant capable of furnishing high pressure gas to Arcadia, Sierra Madre and the intervening districts to the west, east and south.

ALAMEDA, CAL.—The contract for supplying the city with fuel oil for the Municipal Electric Light and Power plant has been awarded by the Electricity Commission to the Associated Oil Company. Under the terms of the contract the city will pay $1 a barrel for a barrel containing 42 gallons. It is estimated that 25,000 will be required during the next 12 months. The Standard Oil Company submitted a bid of $1 a barrel and the Union Oil Company a bid of $1.05 a barrel. The Associated Oil Company has been supplying the city with its fuel oil for nearly ten years.

SALINAS, CAL.—A force of the Monterey County Gas and Electric Company under Adnah D. Clark has commenced work on the transmission line that is to be built from this city to Spreckels to supply the factory town with electricity. The work has been in contemplation for some time and when it is completed Salinas, Spreckels and other places along the line will be supplied with electricity for lighting and power purposes from the plant at Monterey. The Salinas plant will not be abandoned, but will be held in reserve. The line from Monterey will follow the Southern Pacific's right of way to Castroville, thence to Salinas and from Salinas to Spreckels. The Monterey men have already extended the line to a point beyond Seaside.

WATERWORKS.

HEMET, CAL.—Lake Hemet Water Company has started to replace all of the domestic water mains on Florida avenue with 10-inch steel pipes from the San Francisco mills.

PORTALES, N. M.—J. B. Priddy, B. Blankenship and W. O. Eldham have returned from Kansas City, where they bought machinery for the Portales water, sewer and light system.

OREGON CITY, ORE.—An increase of 300,000 gallons daily in the filtration capacity of the Oregon City water plant has been determined upon and an order has been placed for the installation of another filter unit, which will give the plant a daily capacity of 2,000,000 gallons.

PASADENA, CAL.—At a meeting of the stockholders of the Rubio Canyon Water Company a resolution was unanimously adopted to increase the capital stock from $185,000 to $200 000. This is for the purpose of building an additional 3,000,000-gallon reservoir, to take care of the increasing population of Altadena.

EVERETT, WASH.—The City Council has passed an ordinance providing for the improvement of Ruckor avenue from the south line of Howitt avenue to the south line of Pacific avenue and Pacific avenue from the coast line of Grand avenue to the west line of Ruckor avenue by paving and the laying of water pipes.

ALAMOGORDO, N. M.—Indications are now that actual construction work on the plant of the Alamogordo Gas Company will be under way by March 1st. The building will be on Raymond avenue. R. G. Ferguson and Walter Harpster of Cleveland are expected here on March 1st with plans and specifications for the plant.

SEATTLE WASH.—The City Council has passed a resolution providing for the improvement of West Fifty-ninth street from Twenty-fourth avenue Northwest to Thirty-second avenue Northwest; and Thirty-second avenue Northwest from West Fifty-ninth street to West Fifty-sixth street, by constructing water mains and fire hydrants.

SALEM, ORE.—Mayor G. F. Rogers and Mountain Water Committee are exerting every energy to formulate plans toward bringing the mountain water system into Salem. A pipe specialist will be engaged to determine the length of life of the pipes of the city mains and the machinery of the present plant.

OAKLAND.—C. E. Gilman, connected with the engineering corps of the Bay Cities Water Company, has opened offices in the First National Bank building. From them he will represent William S. Tevis, president of the company, in all matters pertaining to the entre of the company into the local field, along plans outlined by Tevis and announced by Councilman B. H. Pendleton at the last meeting of the City Council.

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Bryant Electric Co. .....
Bridgeport, Conn.
San Francisco, 609 Mission.

Buxbaum & Cooley .....
Seattle, 69 Columbia St.

C

Cal. Incandescent Lamp Co. 2
San Francisco, 669 Mission.

Crocker-Wheeler Company .....
Ampere, N. J.
San Francisco, 195 Fremont.

Cutter Company, The .....
Philadelphia, Pa.
San Francisco, 770 Folsom.
Seattle, 416 American Bank Building.

D

D. & W. Fuse Co. .....
Providence, R. I.

Dearborn Drug & Chem. Works .. 5
Chicago, Postal Bldg.
San Francisco, 301 Front.
Los Angeles, 355 E. 2d.

Duncan Elec. Mfg. Co. 5
Lafayette, Indiana.
San Francisco. 61 Second.

E

Electric Goods Mfg. Co. .....
Boston, Mass.
San Francisco, 165 Second.

Electric Storage Battery Co. .....
Philadelphia, Pa.
San Francisco, Crocker, Big.

F

Fort Wayne Electric Works .....
Fort Wayne, Ind.
San Francisco, 604 Mission.
Seattle, Colman Bldg.

G

General Electric Co. 12
Schenectady, N. Y.
San Francisco. Union Trust Bldg.
Los Angeles, Delta Bldg.
Seattle, Colman Bldg.
Portland, Worcester Bldg.
Atlanta, Ga.
Baltimore, Md.
Boston, Mass.
Buffalo, N. Y.
Butte, Mont.
Charleston, W. Va.
Charlotte, N. C.
Chicago, Ill.
Cincinnati, O.
Cleveland, O.
Columbus, O.
Denver, Colo.
Duluth, Minn.
Indianapolis, Ind.
Kansas City, Mo.
Minneapolis, Minn.
Nashville, Tenn.
New Haven, Conn.
New Orleans, La.
New York, N. Y.
Philadelphia, Pa.
Pittsburg, Pa.
Richmond, Va.
Salt Lake City, Utah.
St. Louis, Mo.
Spokane, Wash.
Syracuse, N. Y.

H

Habinshaw Wire Co. .....
New York, 253 Broadway.

Henshaw, Bulkley & Co. 1
San Francisco, 19 Fremont.
Oakland, 1436 5th.
Los Angeles, 262 S. Los Angeles.

Hughes & Co., E. C. 5
San Francisco, 147 - 151 Minna.

Hunt, Mirk & Co. 6
San Francisco, 141 Second.

I

Indiana Rubber & Ins. Wire Co. 1
Jonesboro, Indiana.

J

Johns-Manville Co., H. W. .....
New York, 100 William.
San Francisco, 159 New Montgomery.
Los Angeles, 203 E. 5th.
Seattle, 576 1st Ave. So.

K

Kellogg Switchb'd & Supply Co. . 13
Chicago.
San Francisco, 88 First.

Kierulff, B. F. Jr. & Co. .....
Los Angeles, 120 S. Los Angeles.

Kilbourne & Clark Company ....
Seattle. 307 Fisrt Ave. South.

Klein, Mathias & Sons 5
Chicago, Station U, 29.
San Francisco, 155 New Montgomery.

L

Lindsley-Wright Co. 3
Portland, Ore., 336 Sherlock Bldg.

Locke Insulator Mfg. Co. 14
Victor, N. Y.
San Francisco, Monadnock Bldg.
Los Angeles, Pacific Electrical Bldg.
Seattle, Colman Bldg.

M

Moore, C. C. & Co., Inc. 3
San Francisco, 99 First.
Los Angeles, Trust Bldg.
Seattle, Mutual Life Bldg.
Portland, Wells-Fargo Bld.

Murdock, Wm. J. Co. 5
Chelsea, Mass.
San Francisco. 162 Minna.

N

New York Insl'td Wire Co. .....
New York, 114 Liberty.
San Francisco, 770 Folsom.
Seattle, 416 American Bank Building.

O

Ohio Brass Co. .....
Mansfield, Ohio
San Francisco, Monadnock Bldg.
Los Angeles, Pac. Electric Bldg.
Seattle, Colman Bldg.

Okonite Co. 1
New York 253 Broadway.

P

Pacific Electric Heating Co. .....
Ontario, California.
Chicago, 558-560 Washington Blvd.

Pacific Gas & Elect. Co., The 2
San Francisco

Pacific Meter Co. 1
San Francisco, 301 Santa Marina Bldg.

Parrott & Co. .....
San Francisco, 320 California.
Los Angeles, Citizens' National Bank.
Portland, Ore., Portland Trust Co. Bldg.
Seattle, Globe Block.
Tacoma, 514 Bank of California Bldg.
Spokane, 161 S. Post.
Honolulu.
Guatemala.

Partrick Carter & Wilkins Co. ....
Philadelphia, 22d and Wood.

Pelton Water Wheel Co., The 2
San Francisco, 1095 Monadnock Bldg

Phillips Insulated Wire Co. 1
Pawtucket. R. I.

Pierson, Roeding & Co. 14
San Francisco, Monadnock Bldg
Los Angeles, Pac. Electric Bldg.
Seattle, Colman Bldg.

Portland Wood Pipe Co. 5
Portland, Ore.

R

Reisinger, Hugo 5
New York, 11 Broadway.

S

Schaw-Batcher Co. Pipe Works ..
Sacramento, Cal., 211 J St.
San Francisco, 356 Market.

Simplex Elect'l Co., The 3
Boston, 110 State.
San Francisco, 612 Howard.
Los Angeles, Security Bldg.
Seattle, Alaska Bldg.
Portland, Couch Bldg.

Simplex Electric Heating Co. .....
Cambridge, Mass.
San Francisco, 612 Howard.
Los Angeles, Security Bldg.
Seattle, Alaska Bldg.
Portland, Couch Bldg.

Southern Pacific Co. 14
San Francisco, Flood Bldg.

Sprague Electric Co. 3
New York City, 527-531 W. 34th.
San Francisco, Atlas Bldg.
Seattle, Colman Bldg.

Standard Und. Cable Co. 1
San Francisco, First National Bank Bldg.
Los Angeles, Union Trust Bldg.
Seattle Office, Lowman Bld.

Sterling Paint Company, ... 5
San Francisco, 118 First.

Swayne, R. B. 5
San Francisco, 813 Postal Telegraph Bldg.

T

Technical Book Shop 4
San Francisco, 604 Mission.

Tel. & Elec. Equip. Co. 3
San Francisco, 612 Howard.
Los Angeles, Security Bldg.
Seattle, Alaska Bldg.
Portland, Couch Bldg.

Thomas and Sons Co., R. .....
New York, 227 Fulton.
East Liverpool, Ohio.

Tracy Engineering Co. 5
San Francisco, 461 Market.
Los Angeles, Central Bldg.

V

Vulcan Electric Heating Co. 4
Chicago. 545 W. Jackson Blvd.

Vulcan Iron Works 1
San Francisco, 604 Mission.

W

Westinghouse. Elec. & Mfg. Co. .. 6
Pittsburg, Pa.
Los Angeles, 527 So. Main St.
Denver, 429 Seventeenth St.
Seattle, Central Bldg.
Salt Lake City, 212-214 So. W. Temple St.
San Francisco, 165 Second St.
Spokane, Columbia Bldg.
Portland, Couch Bldg.
Butte, 52 E. Granite St.
Canada, Canadian-Westinghouse Co., Ltd., Hamilton, Ontario.
Mexico, G. &. O. Baniff & Co., City of Mexico.

Westinghouse Machine Co. 6
Pittsburg, Pa.
San Francisco, 141 Second.

Weston Elect'l. Instrument Co. ... 14
Waverly Park, N. J.
New York, 114 Liberty.
San Francisco, 682 - 684 Mission.

Wilbur, G. A. 5
San Francisco, 61 Second.